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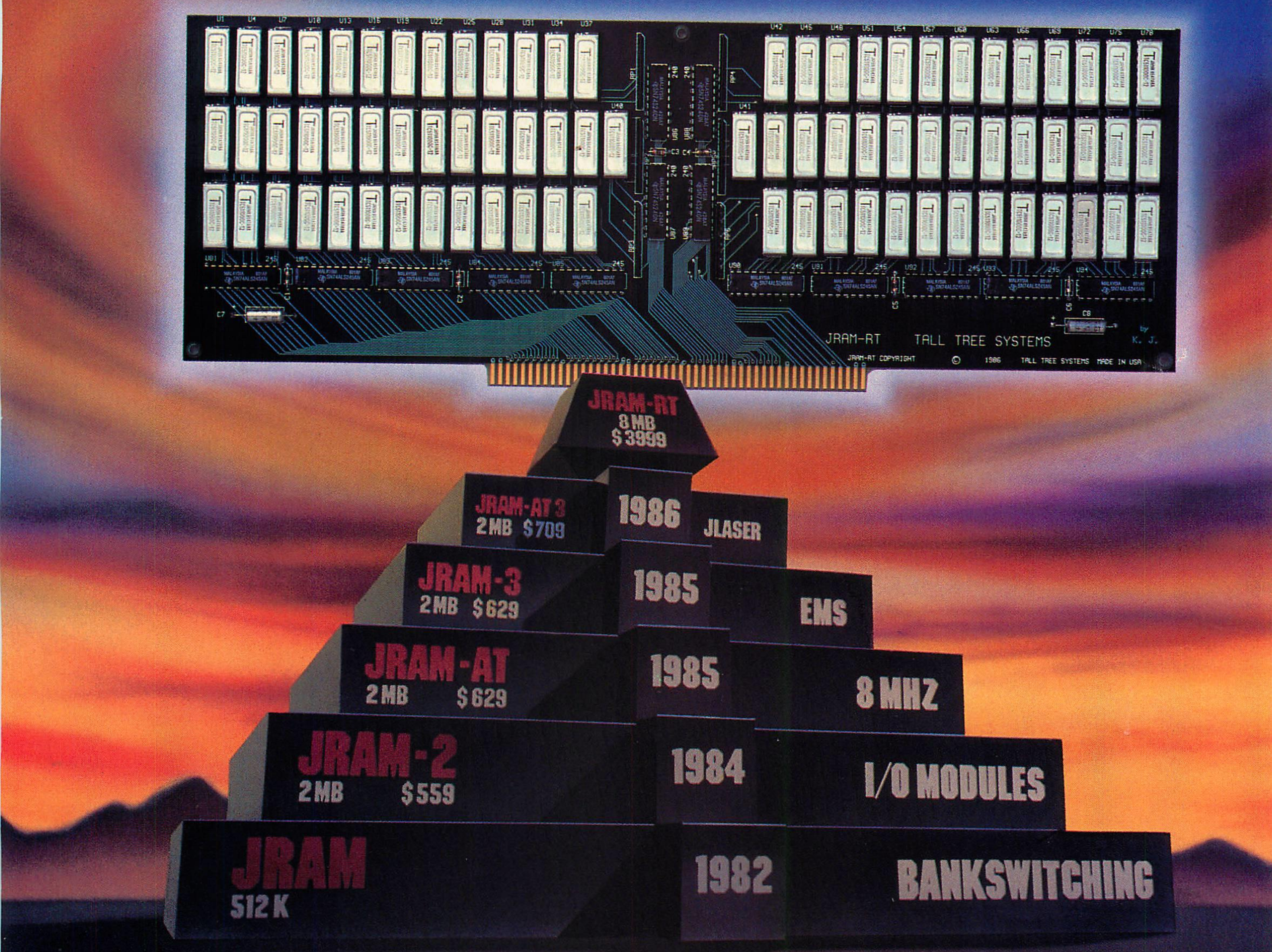

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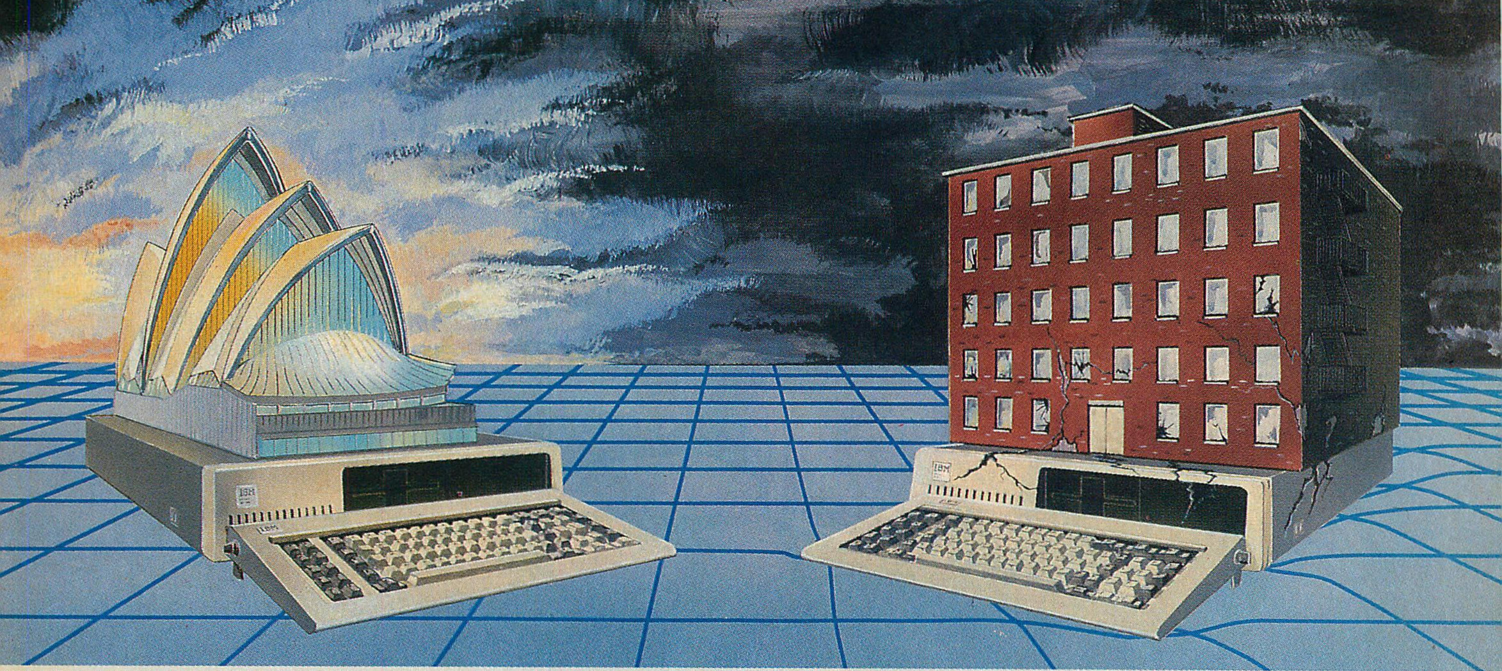
QNX vs UNIX

A QUESTION OF ARCHITECTURE



What do QNX and UNIX have to do with architectural design?
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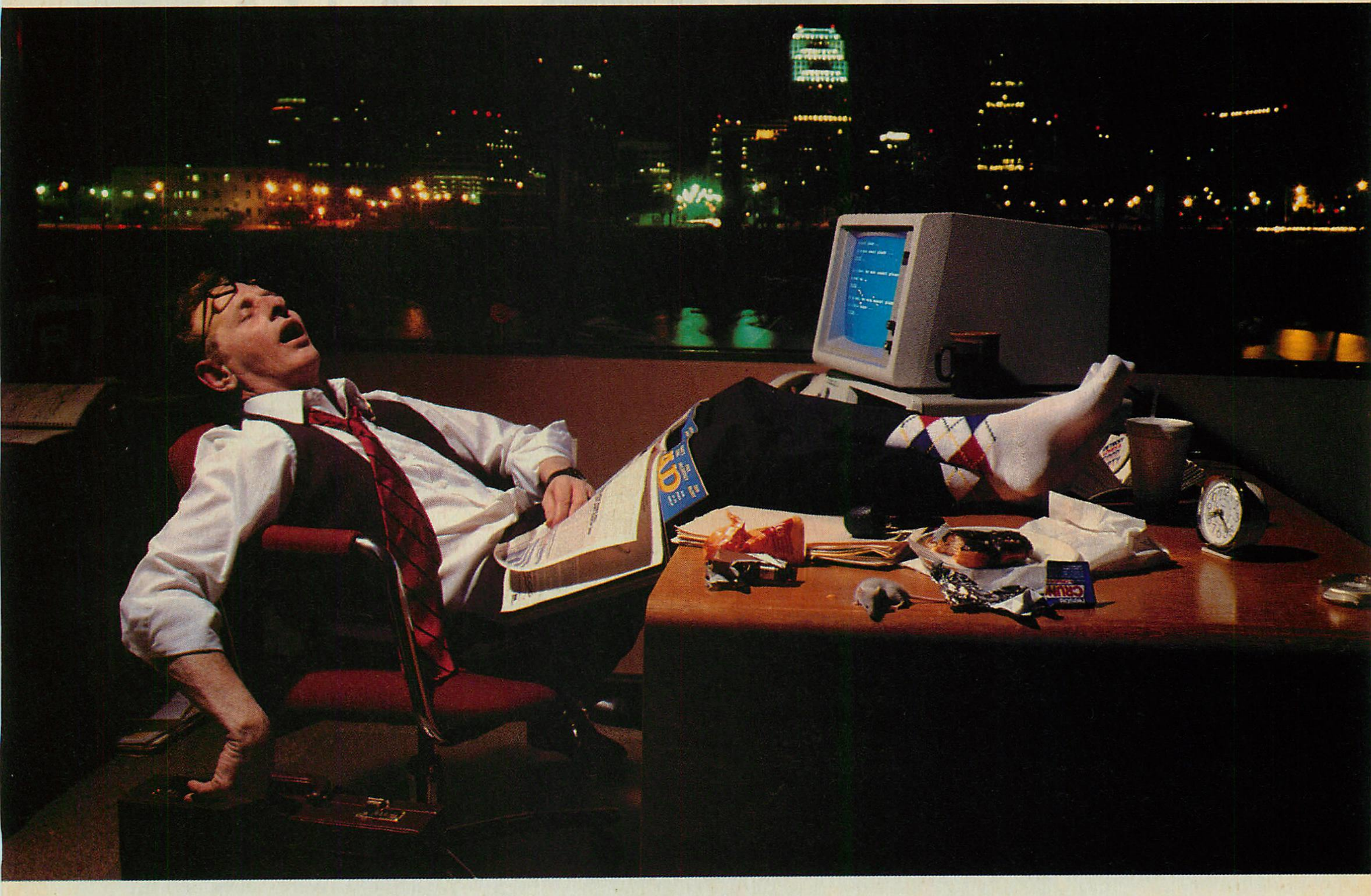

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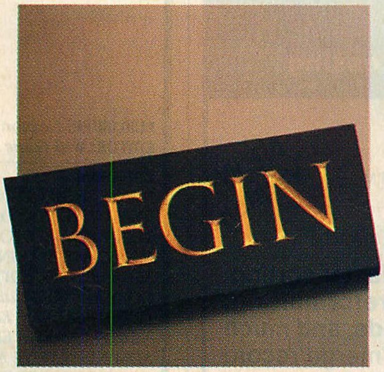

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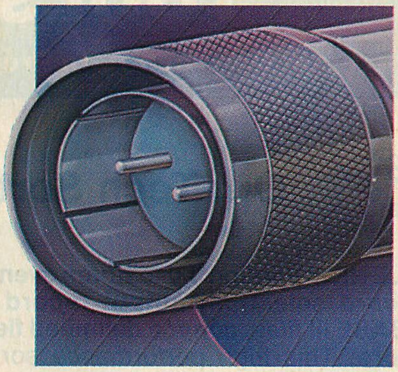

The 5251 Connection 76

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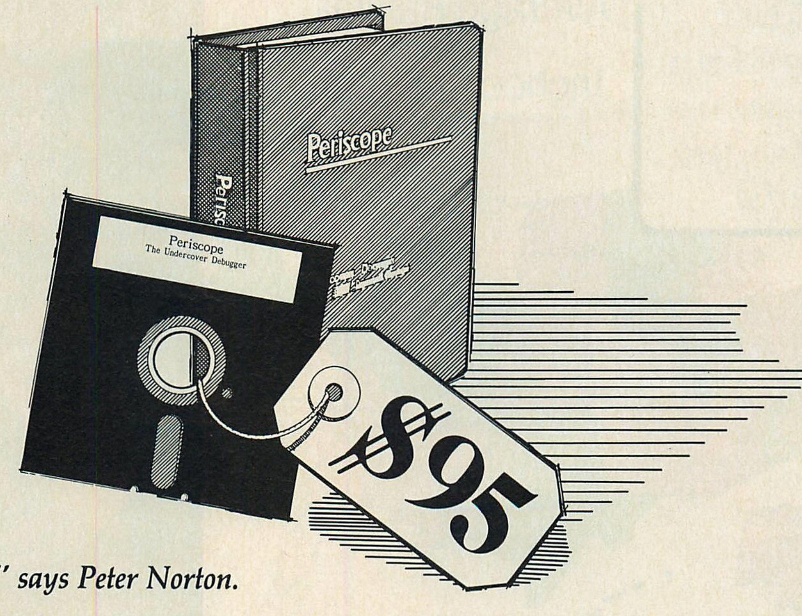
Save On New Model of Periscope



"A marvelous debugging tool..." says Peter Norton.

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- ***"This symbolic debugger, with its breakout button and powerful command options, stands unrivaled for its flexibility . . . Periscope's diverse features, affordable price, and portability place it in a class by itself."*** —Ward Christensen, "Breaking out with Periscope," *PC Tech Journal*, 3/86
- ***"Periscope represents the finest software debugger available in its class."*** — Andrew Fried, *Computer Shopper*, 4/86

Other reviews have appeared in *Computer Language* (3/86), the Boston Computer Society's PC Report (1&2/85), and *Programmer's Journal* (Vol. 3, No. 1).

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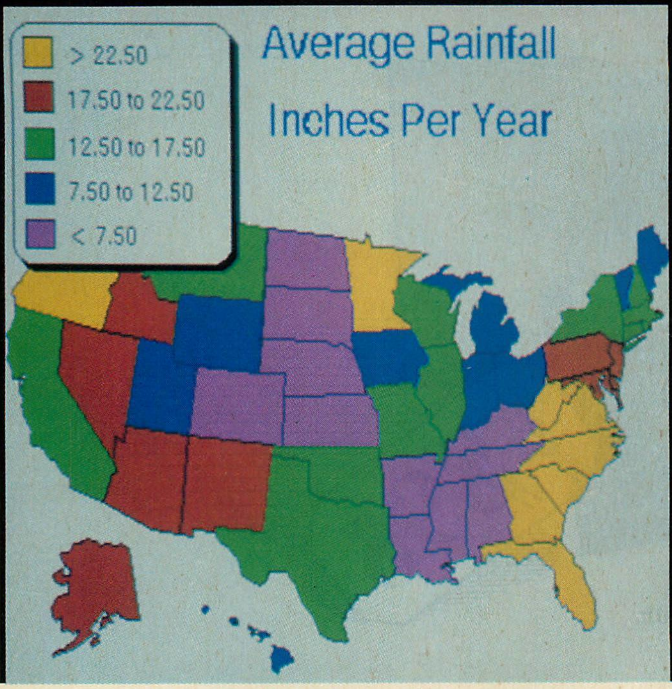
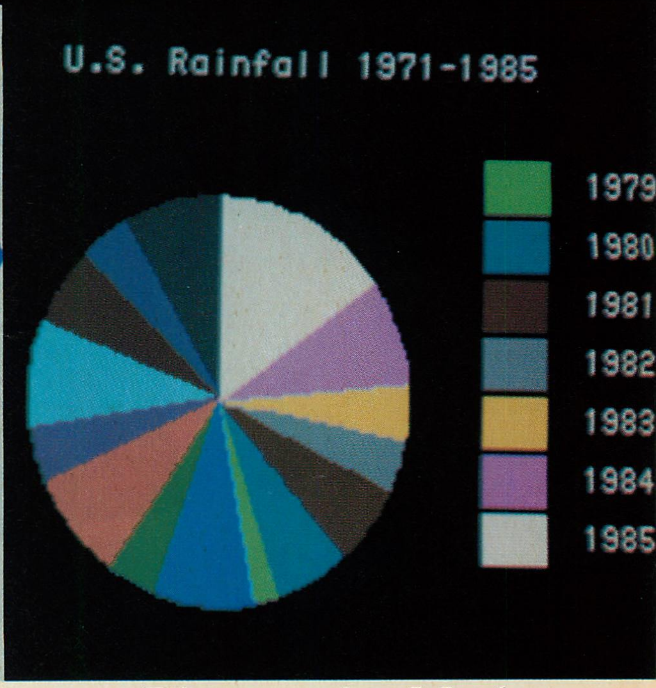


EGA Mode



Plantronics Mode

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AutoSwitch. Only Paradise has it.

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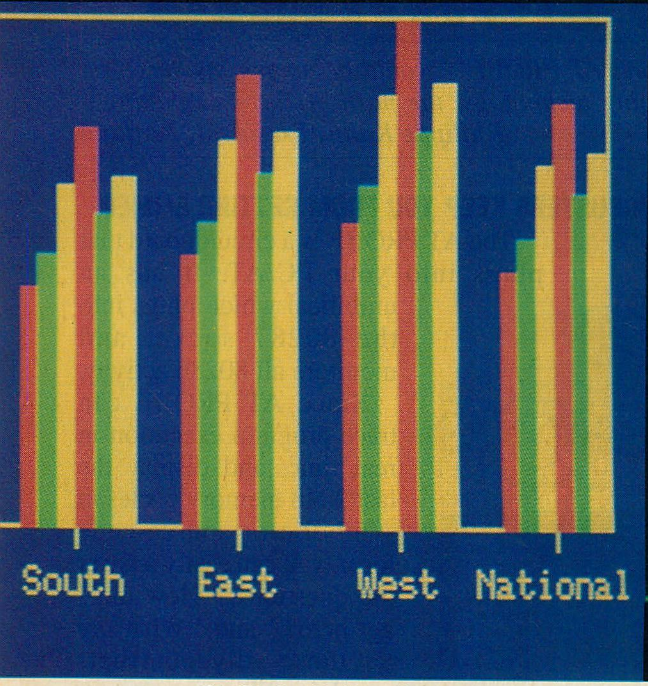
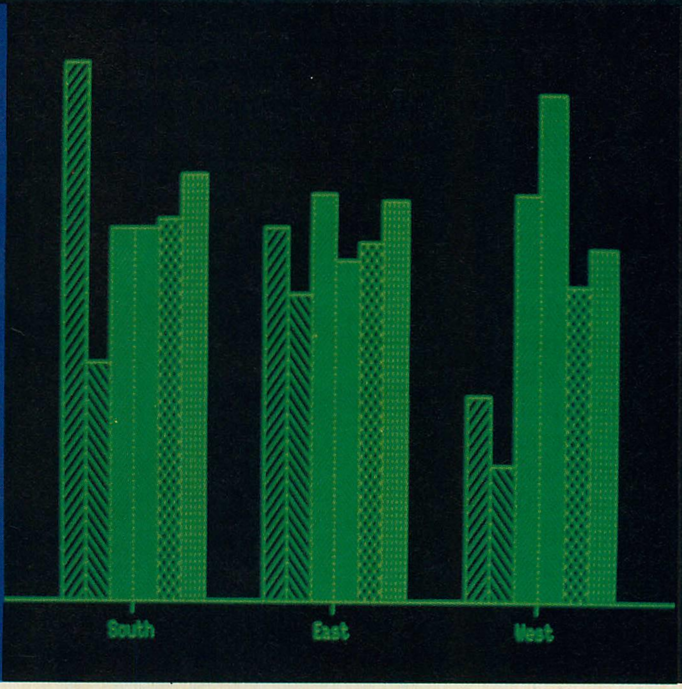


CGA Mode



Hercules Mode

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The Paradise AutoSwitch EGA Card. Just what you would expect from the innovators in Video Technology.

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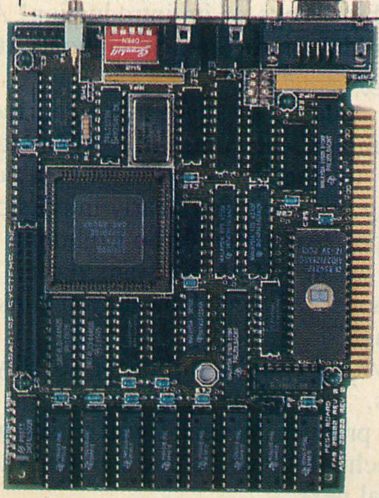
SYSTEMS, INC

The Paradise AutoSwitch EGA Card



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Philippe Kahn, President, Borland

HOW BORLAND DOES SO MUCH, SO WELL, SO FAST

We asked Borland International president Philippe Kahn to share his secrets for rapidly taking a good idea and turning it into rock-solid reality. How does the Borland team do so much, so well, so fast?

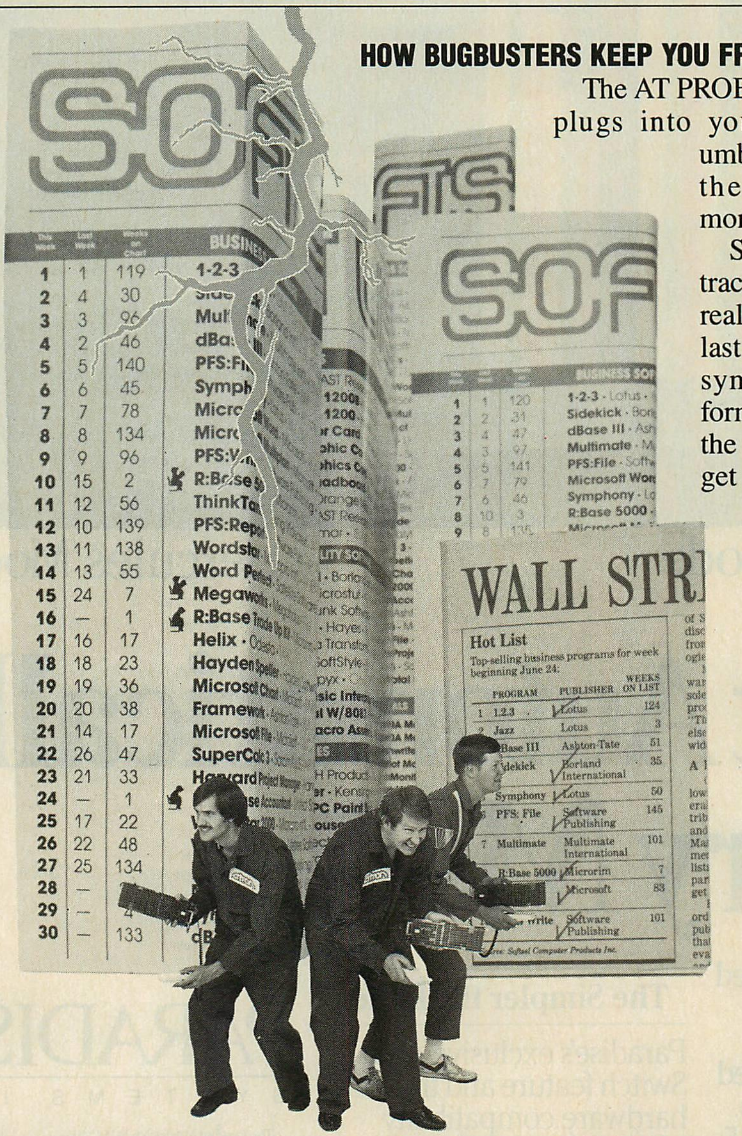
He begins, "I remember when Atron used the June 24, 1985 *Wall Street Journal* chart of top-selling software in an ad." [Note: At that time, seven of the top ten software packages were created by Atron customers; it's now now nine out of ten.] "SideKick was number four, and I let Atron quote me in saying that there wouldn't have been a SideKick without Atron's hardware-assisted debuggers.

"You might say lightning has literally struck again. Turbo Lightning made number four on *SoftSel's Hotlist* within weeks of its introduction! And again, I say we couldn't have done it without Atron debugging technology.

"Cleverly written code is, by definition tight, recursive, and terribly complex," he continues. "Without the ability to externally track the execution of this code, competent debugging becomes very nearly impossible."

Concludes Philippe, "And after Turbo Lightning was solid and reliable, Atron tuning software turned our Probes into performance analyzers. How do you think we *greased* our lightning?"

Philippe, along with a couple million or so of your satisfied customers, we say congratulations on yet another best-selling product. We can't wait to see what awesomely useful technology will come shooting out of Borland International next.



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It can solve *spooky* debugging problems. Like finding where your program overwrites memory or I/O - impossible with software debuggers.

You can even do source-level debugging in your favorite language, like C, Pascal or assembler. And after your application is debugged, the AT PROBE's performance measurement software can isolate performance bottlenecks.

Finally, the AT PROBE has its own 1-MByte of memory. Hidden and write-protected. How else could you develop that really large program, where the symbol table would otherwise take up most of memory.

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Objects and Attributes

Our operating systems need to get smarter.

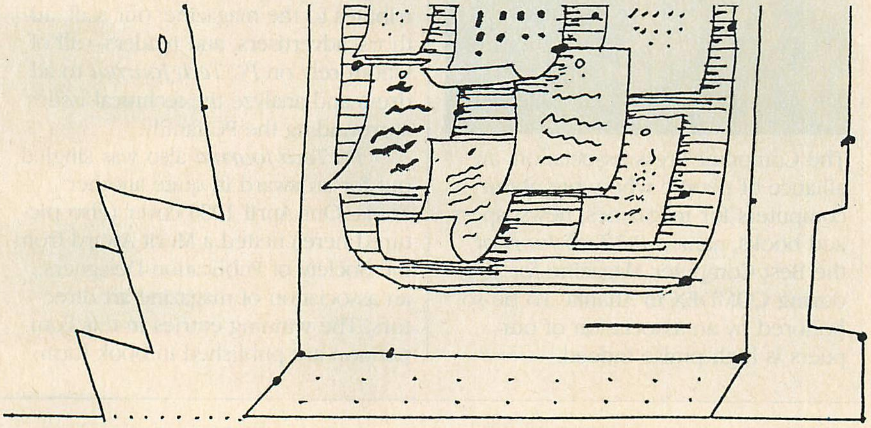
One of my computer science professors gave me an assignment that I now look back on with some satisfaction. It involved a network routing program to be written in LISP, and it came with a challenge: the fastest program would earn extra credit. The speed challenge spurred me on to read the MIT "blue book" (the bible of LISP) inside and out in an effort to learn anything that would help. As it turns out, I learned something very important.

In LISP, I had been taught, the atom was the smallest object, indivisible. What I discovered in the blue book was that the property list (or p-list) attached to each atom could be modified to attach arbitrarily complex data structures "below" that lowly atom. The long-term effect on my thinking was significant. I had learned to attach attributes to objects.

In simple terms, objects can be manipulated. They have certain characteristics, or attributes, that are inherent and some that can be induced. A baseball, for example, is an object that is often manipulated. Some of its attributes that come quickly to mind are color, texture, weight, shape, and surface tension; a baseball also can be considered to have these perhaps less obvious attributes: position in space, spatial orientation, velocity, and acceleration. Although some attributes remain fixed, some can be altered. Manipulation of a baseball with a device called a bat, for example, can alter its attributes.

The manipulation of computer-based objects may be less satisfying than clobbering a small orb, but certainly no less difficult. Worse, computers and software do a poor job of managing an object's attributes.

The object of most interest to most computer users is the file. Files hold all of the data upon which spreadsheets, word processors, and data management programs operate. Those files are packed full of information, but what do



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we actually know about them? We can tell if the file is a file or a file of files (a directory). We can determine the file's size, although the number is ambiguous for directories (that is, should it be the size of the directory file itself or the total of all that is contained in the directory?). Files usually are stamped with the date and time of their creation or last modification. Additionally, most operating systems allow a small set of other attributes to be attached to the file, such as those provided by DOS (archive, hidden, read-only, system, label, and subdirectory).

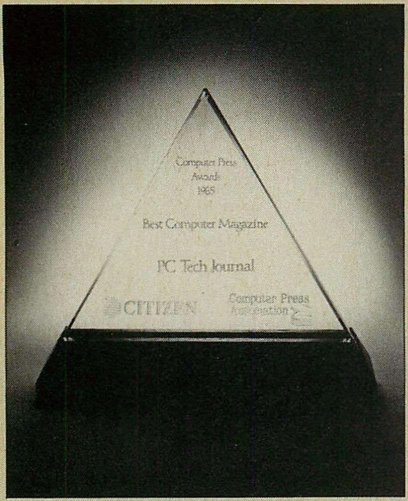
The set of attributes for files is hardly enough. Recognizing this, DOS developers devised a file name that consists of the name itself and an extension to the name, intended to be the file type. Microsoft Windows allows files to be displayed by name, size, date, and *kind*, another way of saying type. Using a file extension as a type is widely practiced by individual software products but is in no way standardized or supported by the underlying operating system. For example, spreadsheet files have no standard type, but rather a plethora of extensions chosen by each manufacturer (.WKS, .SS, .CAL, .VC, .MP, .MPW, etc.). File name extensions are thus used as attributes but not supported as such by DOS.

What other kinds of attributes might a file object need? The answer, which may sound flippant, is whatever attribute a user might choose to attach to a particular file. Many spring to mind, but here is a simple one. How about a set of attributes that tells a backup program how frequently files need to be archived? For example, the set of attributes could consist of DAILY, WEEKLY, MONTHLY, ALWAYS, and NEVER. The backup program could be invoked with an appropriate parameter and only those files with the related attributes would be manipulated; files with no backup attribute might default to a strong attribute, such as ALWAYS.

It is tempting to say, "OK, let's add 16 more bits to the attribute field in the directory and add some specific attributes for the backup process." I am suggesting something more radical, however. Let's add a general facility for attaching arbitrarily complex, *symbolic* attributes to the file object.

For some objects on the standard desktop computer, this is now done, albeit in a complex and technical way. The computer I am using to write this editorial has a mouse attached to COM2: and a device driver installed in memory that, in effect, attributes a mouse to that serial port. What is missing from this configuration is anything

BEST COMPUTER MAGAZINE: PC TECH JOURNAL!



The Computer Press Association, an alliance of people who write about computers for magazines, newspapers, and books, named *PC Tech Journal* the Best Computer Magazine for 1985 during COMDEX in Atlanta. To be so honored by an association of our peers is high praise indeed.

The citation read, in part, "*PC Tech Journal* has substance, style, and clear writing combined with superior information value and contemporary graphics. Each issue contains useful techniques for PC users. Its graphics are clear and consistent and show good magazine technique. Its covers are designed with imagination, even though they are highly technical."

As proud as I was of the beautiful trophy pictured here, I accepted the award on behalf of everyone who contributes to the magazine: our staff, authors, advertisers, and readers—all of whom rely on *PC Tech Journal* to address and analyze the technical issues surrounding the PC family.

PC Tech Journal also was singled out for an award in quite another arena. Our April 1985 cover (also pictured here) netted a Merit Award from the Society of Publication Designers, an association of magazine art directors. The winning entries in this competition are published in book form;

many art directors consult this annual publication for inspiration and ideas, so we are delighted to be part of it. Deciding how to illustrate some of our more abstract and technical subjects is often a real challenge, so we are especially proud of this honor.

—*WF*

that really *knows* that I have a mouse attached. Wouldn't it be nice if I could run the ATTRIBUTES program and assign the attribute "MOUSE ATTACHED" to COM2:? Then I could attach the attribute "MOUSE DEVICE DRIVER" to the file holding the device driver. Even if I had to write a configuration file that said "LOAD MOUSE DRIVER," I could do so symbolically rather than writing "DEVICE = \UTIL\MOUSE.SYS". The operating system would know it had to load mouse software and would simply search until it found the right combination of software and ports.

A clear advantage of this strategy is that it is no longer dependent upon specific file names or specific hardware. If I wished to test a new driver for the mouse or even a new and different mouse, I could simply attach the attributes and reboot the system.

Critics of this idea might correctly argue that my fictional ATTRIBUTES program involves as much work as running a text editor in order to modify CONFIG.SYS or AUTOEXEC.BAT. While true, the argument begs the issue of more complex attributes that might be useful for files. One example of particular contemporary importance is that of a collection of files that form the object. Data managers often place data in one file, indices in one or more files, and other kinds of information in still more files. Yet the set of files is what is important to the user. If a particular database is to be archived, the user would want to order a backup of the database object, not each individual element. The user might not even *know* the name of each individual element and should certainly not be required to. In such cases, a user (or the program itself) might define a new object (the database) with a set of attributes (the names of the files that make up the database).

A new product attempts to address this need in an interesting, although not entirely successful, way. SmartNotes is an electronic version of the immensely popular Post-it notes from 3M. This program, which allows a user to attach a little note anywhere, is intended to be used just as its paper counterpart: the user can "stick" a note on a page of a document in a word processor or in a cell of a spreadsheet. The contents of the note are arbitrary, and the note pops up when the page or cell is next examined. A note even can be attached to a file name in a file listing generated by the DIR command. Although other programs cannot operate based on the contents of notes that may be so attached, the user is given visual cues that can be quite helpful.

SmartNotes' major weakness is that the attached notes must be stored somewhere, and that somewhere is most decidedly not with the file to which the notes are attached. For example, if I attach a note to this editorial's manuscript file and then copy the file onto diskette, the note stays on my hard disk and will be lost to the person who reads the diskette.

Consider what would happen if attributes could be attached to file objects and other objects defined. First, a file could be tagged with an attribute indicating that notes were attached. A group object could be created that consisted of the file and its associated note file. Then when the COPY command was used, the group would move to the diskette. Better yet, the notes could be stored as attributes themselves, automatically following the file with no additional work from the user.

This concept can be extended to include the attachment of attributes to just about every object associated with the desktop computer. While some may argue that such methodology adds up to considerable overhead, I contend that the rising performance and capacity of the desktop, coupled with the fact the attributes do not have to be assigned if the user prefers to operate without them, make this concept viable.

By the way, I won the LISP speed challenge. How? By being the only student to discover the COMPILE function of LISP 1.5.

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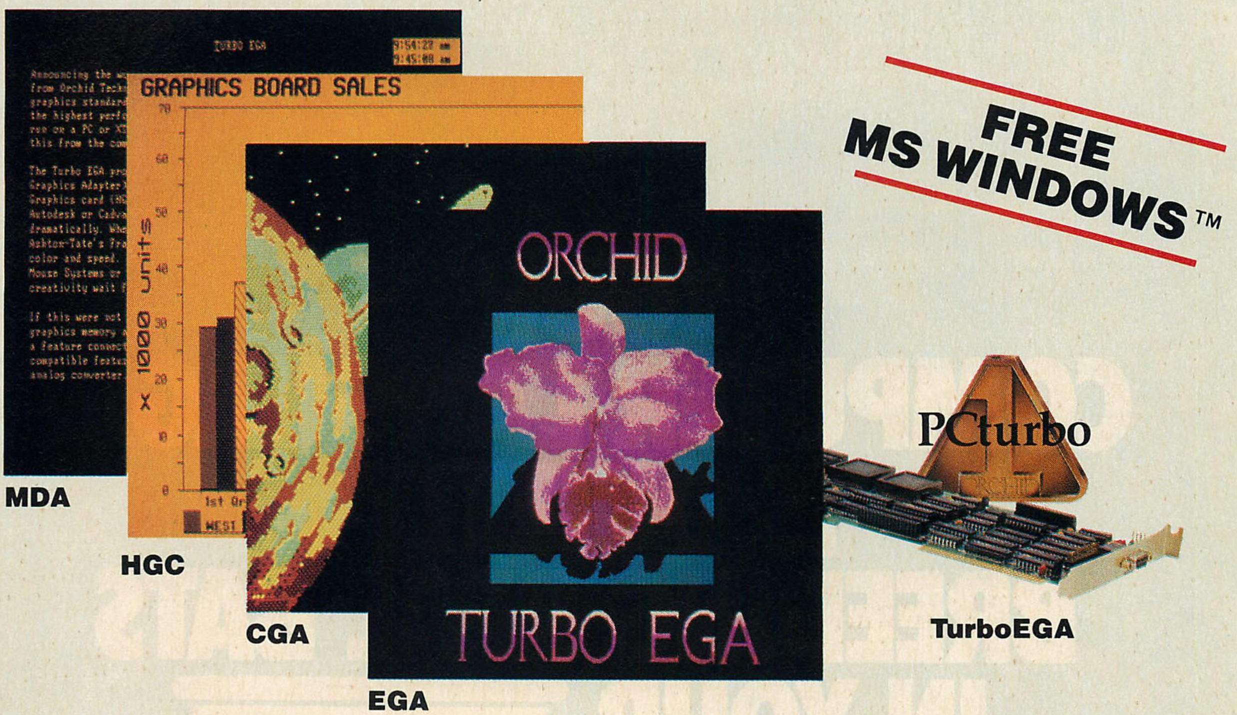

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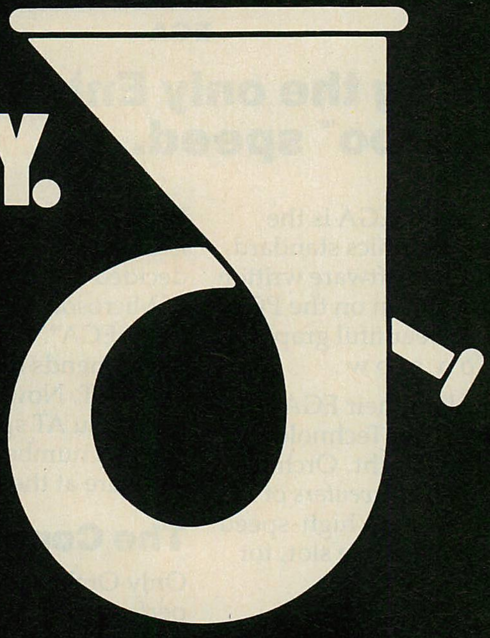

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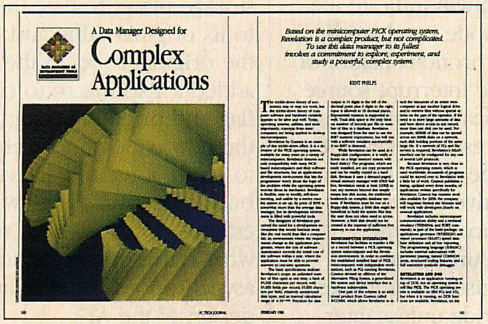
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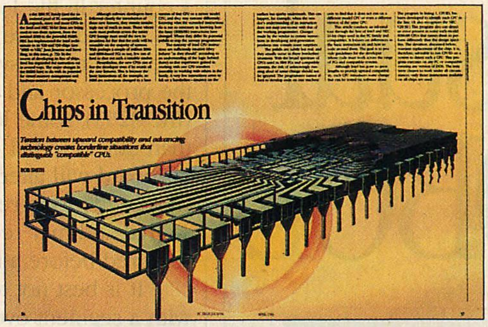
KENT PHELPS


Chips in Transition

Tension between upward compatibility and advancing technology creates borderline situations that distinguish "compatible" CPUs.

TRAITS REVEALED

Thank you for the review of Revelation in the February 1986 issue ("A Data Manager Designed for Complex Applications," Kent Phelps, p. 160). It was generally well done, although I think more attention could have been given to multivalued fields, a powerful and distinctive Revelation trait.

I have been working with Revelation for approximately a year and a half, yet Mr. Phelps has managed to write about some things of which I was not aware. For one thing, I do not think Cosmos would agree that "Backups are allowed for personal use." On another point, R/LIST does not change from columnar to vertical format if the total column widths exceed the device width. I wish it did. The only way that I know to produce a vertical format is to create a symbolic field.

Also, I have never heard of REFORMAT. The description of it reminds me a little of INVERT.ALL, a supplemental program to R/DESIGN's cross-reference function, which, by the way, is one of Revelation's more powerful features (and, unfortunately, was not mentioned in the review). Essentially, the feature allows the automatic maintenance of inverted indexes that may be linked with other files. This means that when one-to-many relationships exist between records in different files, dynamic links may be created between the records allowing all of the data from either file to be available to the related records in the other file. This involves creating symbolic fields, but complex networks of data relationships may be created and automatically maintained by R/DESIGN.

Finally, listing 1, BENCH3.LST, has an error: the line of code that reads 'ARRAY(POS) = STATE' replaces the contents of the POS element of ARRAY with the value of STATE. What is desired is that the value of STATE be inserted into the middle of ARRAY at position POS, effectively increasing the position of all subsequent elements by one. To achieve this, the line should be replaced by the following lines:

```
ARRAY = INSERT(ARRAY,POS,0,0,STATE)
ARRAY1 = INSERT (ARRAY1,POS,0,0,0)
```

Stephen Montgomery
Systems Consultation
Chicago, IL

Mr. Montgomery is correct. The ability to use multivalued fields is an important feature of Revelation: coupled with variable length fields and the practical lack of restraints on how many multivalues may exist, quite complex data structures may be implemented.

Cosmos has employed a reasonable approach to the issue of software protection, relying on a sticker that accompanies the product and which is to be affixed by the user to the CPU that is designated to operate Revelation. The copy protection does not prevent or restrict use from a hard disk, but the start-up message informs and reminds the operator each time that the use of the system does not conform to the licensing agreement—that is, if the sticker is not present on the machine. I believe that Cosmos has done what it can to establish and assert its right without burdening the legal owner of the product; most other copy-protection solutions fall short in one direction or the other.

You are correct concerning the vertical format of R/LIST reports. The description given in the article is true of real PICK systems, and it would be preferable if Revelation performed this way also: more readable reports would be produced for those times when the total column width needed exceeds screen size, or for when the total report width is unpredictable. Presently, Revelation wraps the output of each field within the column space allocated for it.

REFORMAT is also a PICK feature that is an inverting tool, but not specifically for the purpose of maintaining inverted indexes, because full PICK systems are seldom index-driven. REFORMAT is a verb that, when executed at command level using R/LIST syntax, builds a work file with items selected from primary file, each item consisting of any array of dictionary items in the order specified. The first dictionary item becomes the item id, *followed by as many other attributes as needed. Thus an ad hoc work file can be created as needed for a special task and then discarded upon its completion.*

Thank you for the correction of the section of code in listing 1.

—Kent Phelps

CHIPS IN QUESTION

Bob Smith's article "Chips in Transition" (April 1986, p. 56) was a useful review of the idiosyncracies of the chips in the 8086 family. Readers should be made aware, however, that one of the work-arounds presented for an 8086/88 problem is flawed.

Mr. Smith correctly notes that a multiprefix instruction (REP MOVSW ES:) will not restart properly if interrupted. But two failure modes can occur, and checking the CX register following these instructions catches only the one in which all repeats have not been performed. If all of the programmed repeats have been completed, the instruction may be executed one more time. In the case of a MOV instruction, this will cause the first location beyond the destination to be clobbered. CX will be zero, as usual, but SI and DI will have been advanced to reflect the unprogrammed execution, which makes their values following the multiprefix instruction unreliable for chained operations.

This can be demonstrated easily on any 8088-based PC. Simply construct a loop to perpetually execute a REP MOVSW ES: instruction, testing each time to see if the location following the

destination has been altered. Including a counter in the loop will indicate that this second failure mode is relatively rare. Due to the synchronous nature of the processor and the interrupt source (the 8253), some loops may take longer than others to fail. Pressing a key at the keyboard will alter the phase relationship of the loop relative to the interrupt source and may reduce the time required before a failure occurs.

It is best not to use string moves with a segment override unless interrupts are disabled *and* NMIs are not possible. (Hardware-assisted debuggers generally use the NMI.) Those programmers who must use segment overrides while interrupts remain enabled should be certain that the information in the location following the destination is not important to their program, and that they do not rely upon the expected register values resulting from the execution of these instructions.

Michael Liebert
North Caldwell, NJ

We downloaded and assembled CPUID.ASM from "Chips in Transition." When we ran it, it hung up our IBM ATs. We went into debug and found that the **fnstenv NDP_ENV** instruction was causing the bug. The problem is that the AT has no NDP and when the address was put on the bus, some other piece of hardware filled memory from the address in the instruction through the end of the data segment with a pattern of repeating double words. The data segment is the same as all the other segments in CPUID so the stack that builds from the end of the segment down was overwritten. The program continues to run until the **ret** at address 223 line 712. The return pops the **ip** of the corrupted stack and execution begins at a random address. We do not know what causes the garbage to fill RAM—however, it does not happen on the AT that has the new-design motherboard (256KB RAM chips).

Our revision of the source code prevents the crash and prints a message indicating that the problem was detected: Just before the **cli** that precedes the **fnstenv** we added 4,096, the number of 16-byte paragraphs in 64K, to the data segment so it points past the current segment. We filled that segment with zeros, then we go through the original code until we are past the **sti**. We check the rest of the new segment to see if the zeros have been altered. If they have, then we set a new flag and jump to **cpu_exit**. Otherwise we copy the 14-byte environment to its initial storage place, restore the data segment to its original value and continue with the original code. In the main line we added a TAB macro to check the new flag and print a message. When we run the new code on a machine that used to crash, it usually detects the condition, but not always. The new code never crashes. We would like to know exactly what causes the error and why it is asynchronous. Is there an error in the design of the AT?

John Lodge
Tim Oliver
Roseland, NJ

Mr. Liebert correctly points out that any work-around based upon post-MOVS tests still can fail. This is yet another reason to avoid using segment overrides with repeated string operations.

Mr. Lodge and Mr. Oliver have encountered an odd problem, one that I ran into recently on an IBM 3270-PC/AT without an 80287. Despite Intel's recommendation on how to tell if a numeric processor is installed, IBM has introduced a hardware anomaly that invalidates Intel's technique. In the short time I had to work on this problem on the 3270, I was unable to construct a work-around, so I am pleased to read of Lodge and Oliver's success. I do not understand why some (but not all) PC/ATs without a 80287 turn and run when confronted with a floating-point instruction. According to the Intel specifications, the 80286 is supposed to execute an INT 07H whose default handler (in the BIOS) contains no hint that it might run amok. On the 3270-PC/AT, I tried installing my own INT 07H handler within CPUID, but the machine still trampled my code. An alternative solution to the problem is to skip the test for a numeric processor when on an 80286. That goes against the take-nothing-for-granted attitude I adopted when writing CPUID, but it is preferable to crashing the machine.

On another matter, I since have discovered one more minor difference between the Intel 8086/88 and the NEC V20/30. As pointed out in the article, the NEC chips correctly disallow interrupts for the single instruction that follows a MOV to or POP into any segment register. However, NEC has taken that prohibition one step further by also disallowing interrupts after a MOV from a segment register. That is, when single-stepping through your code on an NEC CPU, expect it not to trace (but, of course, still execute) the instruction that

follows code such as MOV AX,DS as well as MOV [...],DS. It would appear that NEC just wants to be careful.

—*Bob Smith*

OF MICE AND USERS

In regards to Jeff Duntemann's review of the new Microsoft Mouse in the March 1986 issue (see Product Watch, p. 179), his complaints about the non-click buttons are ridiculous. His comment is "Without a solid, snappy click from the mouse switch, the user must watch the screen to see if the desired selection took place." Mr. Duntemann sees this as a disadvantage. My comment would be that without clairvoyant powers beyond my ken, if the user is not already watching the screen, he has very little chance of landing the mouse in the proper place before he clicks it. He therefore will see a response from the system if he has successfully clicked the mouse. Personally, I would rather not have a mouse that makes sounds like a child's click toy (or the IBM PC keyboard, for that matter).

Kudos for Ted Mirecki's review of Peter Norton's *Programmer's Guide to the IBM PC* ("Keeping the Family Straight," Book Reviews, March 1986, p. 193). I share his sentiments exactly regarding the completeness of the coverage of the subjects in this volume. I often find that, in his articles, Mr. Norton has a tendency to stop discussing things when they begin to become interesting. It leaves the feeling that he does not want us to know as much as he does. I got the same feeling from reading this book, and I am glad to see that someone else has noticed this.

Matt Richards
Baltimore, MD

A tactile/audible mouse click is a way of passing some of the necessary feedback of an interactive task from my eyes onto my hands. The visual channel of the man/machine interface is already taken up by my application—I do not want to be obliged to monitor system matters (like whether or not the mouse button has closed) in the visual channel if my hand can do the job as well.

Furthermore, nothing obligates an application to give a visual indication when a mouse selection is made. Good design would require it—but good design is far from universal. The snappy mouse click tells me that I have not fumbled; that I have, in fact, pressed hard enough on the button to make it connect. Microsoft's new buttons sometimes leave me wondering, and that is a most unwelcome distraction from whatever job is at hand.

The IBM keyboard is noisier than it has to be—much noisier than any mouse I have ever used. And let's not forget the XT and AT power supply fans, which also are extremely loud and obtrusive. You seem to have a preference for computing in silence, something I also wish for from time to time. Perhaps IBM will consider the virtues and problems of silent computing in designing future members of the PC family.

—*JD*

NOT JUST A REFLEX

Your recent Product Watch review of Reflex (William Casey, April 1986, p.189) omitted several of that program's more important features.

Reflex has an excellent mouse interface. For example, the width of a column can be changed simply by clicking and dragging the column's right border. Similarly, when designing a report, the position of an item can be changed by dragging it to the desired location. Reflex flies with a mouse. In addition, field length is not fixed, but is as long as needed for each record; thus, disk and memory space are not wasted

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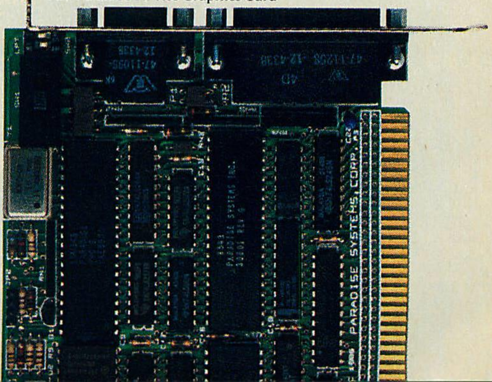

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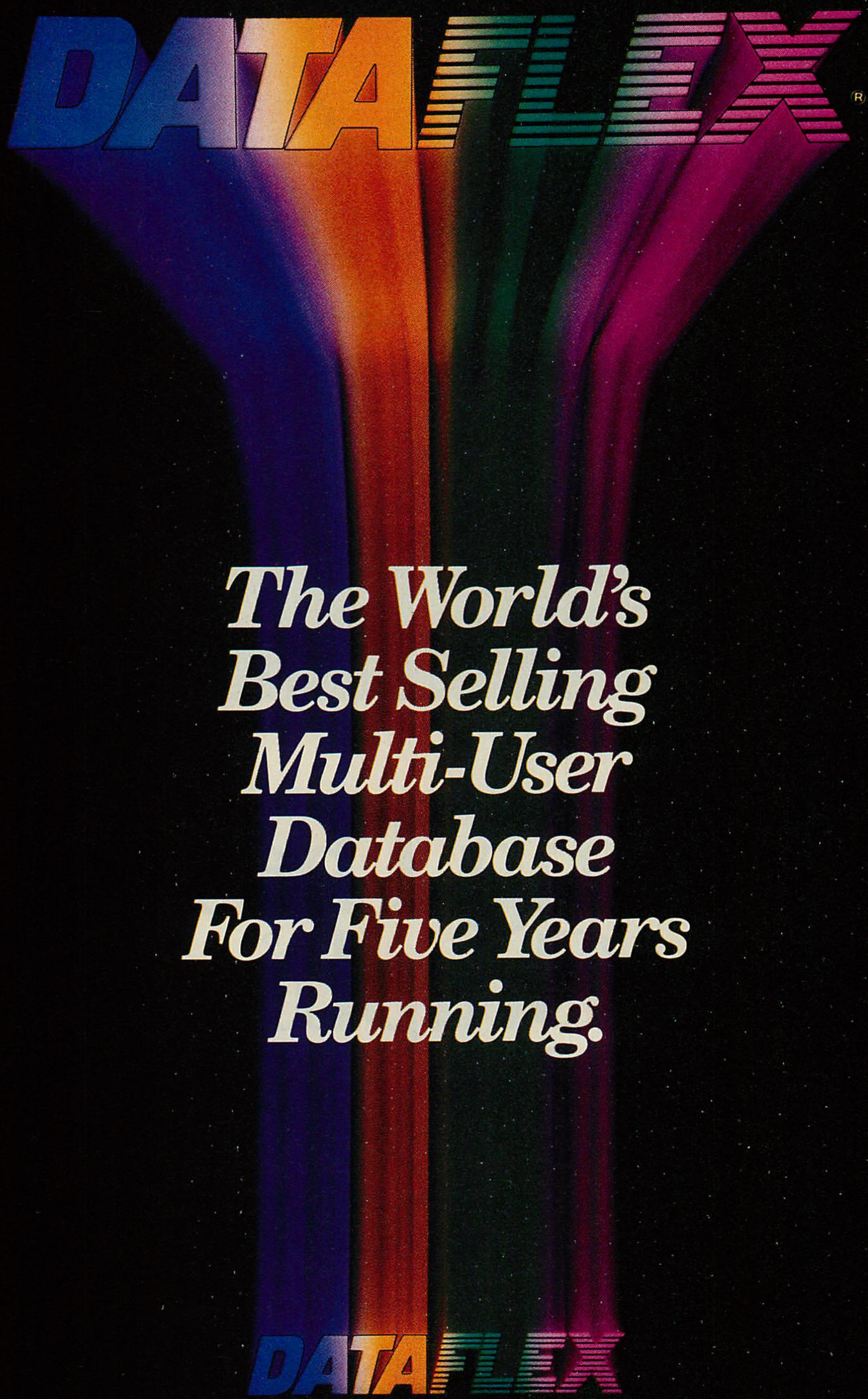

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storing mostly empty records. For example, a 98,000-byte dBASE II file was reduced to less than 50,000 bytes when translated to Reflex format. The updated version of Reflex (available to current owners for $10) supports the LIM expanded memory specification, so memory limitations should be no problem. Finally, the report generator allows you to preview the appearance of the printed report on the screen. This feature, particularly when used with a mouse, permits the easiest and fastest report design I have ever seen.

As your review noted, Reflex has no relational capabilities and should be considered as a file management system. At any price it would be a great program, but at $99, it is a steal.

Peter G. Aitken
Durham, NC

HIGH C

I have been using Lattice C 2.15 for several months to develop a data entry program for a client. The program is split into 33 source code files, most containing two or more C functions, plus three assembly language functions. The compiler has performed without problem during development.

After reading the excellent review of C compilers in your January 1986 issue ("The State of C," William J. Hunt, p. 82), I could not wait to get my copy of Lattice C 3.0. As soon as I received it, I made a copy of my client's program and began a mini evaluation of my own. Here are my findings:

I compiled the program using the LC command and was immediately impressed. The compiler began issuing warning messages for variables that I had defined and never used and for variables I was using before a value had been assigned to them. In one of the source files, the compiler issued the message "statement has no effect." That statement, **x == 1;**, was a data entry error on my part. Thus, the compiler found a bug in my program that I did not know about (the program was executing "correctly" despite this error).

I linked the program without error and attempted to execute it. It failed immediately. I isolated the failure to the use of the escape sequence \\ in a character string in a **sprintf** statement. This was a problem known to Lattice and was fixed in the next version. I exchanged my diskettes (at no charge other than some postage) for the next version. I apparently exchanged 3.0e for 3.0g or 3.0h—it is difficult to identify exactly which of these two I had, because the compiler does not display its complete version number.

The next program failure I found is a problem with the C language. My program cannot read the data files created by its 2.15 cousin because the data records in the files are defined as **structs**, and the 3.0 compiler aligns **structs** differently than the 2.15 compiler (2.15 generated fill bytes, 3.0 did not). The compilers do have options on the command line to change the way data alignment is done, but this is the wrong place to control alignment. These options are global and do not help if, in the same program, some **structs** need to be aligned and some do not. This is a real problem if your C program is trying to read the output of other programs. This is not a problem that was caused by or can be corrected by Lattice. The ANSI C committee should add an unaligned modifier that can be used like the unsigned modifier, to all data types. (I have not seen the ANSI C standard document; perhaps something like this has been done already.)

I recreated the data files and immediately found another problem. This time it was the **strncpy** function that was not working the same as it did in 2.15. The 3.0 **strncpy** does not null terminate the result string. I created my own version of **strncpy** that is 2.15 compatible and now the program really does work. Lattice changed **strncpy** to conform with the ANSI standard.

Overall I am impressed with the Lattice C 3.0 compiler. I feel safe using it for any future development; however, great care must be taken when users are converting an existing program from the 2.x to the 3.0 compiler.

While I was evaluating the Lattice compiler, my client was evaluating the Microsoft C 3.0 compiler using the same program. The Microsoft compiler does not produce any of the nice warning messages that the Lattice compiler produced, and the program cannot be linked because it uses the **peek** and **poke** functions. Microsoft removed these functions from its 3.0 library. In addition, in order to execute the program, I would have to modify the assembly language subroutines (because Microsoft uses a different functions calling sequence on the stack).

Hale Landis
Louisville, CO

BUGGED

Your Product of the Month for January 1986, entitled "Structured Debugging" (Jeff Duntemann, p. 29) makes me won-

der whether you go beyond the manufacturers' press releases when you make your selection for this column.

You say that the product's most noteworthy feature is its protected memory board, which contains debugger code and is thus protected from the unruly behavior of the program being observed. Granted, this line is in the advertising copy of many debuggers on the market today. However, my experience (which includes the use of DEBUG, SYMDEB, ATRON PC Probe, and Intel ICE) indicates that it actually does not count for very much.

First, the path to the protected debugger code still lies in RAM, either at the breakpoint location where debuggers temporarily place an INT 03H instruction or at the vectors for the INT 03H or NMI interrupts. These locations could be hardware protected, but the article implies that this product does not have such a feature, and, of course, if a required RAM location gets wiped out, the protected code will not do much good. Second, claims about protected debugger code imply that overwriting is a frequent failing of untested software, yet in six months of ATRON use I cannot recall trapping because of an attempted access to the ATRON protected locations. (I even had to verify that such a trap would occur by writing test code.) Third, even if one were to get back to the debugger, he would not have much to look at if his code, data, and/or DOS had been overwritten.

The baseline product to which the Product of the Month is compared is DOS DEBUG. To my mind, this is almost like comparing it to switches and lights, as SYMDEB (supplied free with the Microsoft Assembler) is certainly the minimum (a very high minimum at that) debugger now used for any serious work. In fact, most of the features of the reviewed product are also features of SYMDEB.

The ATRON PC Probe is used as the top-of-the-line for comparison purposes. Certainly this is a good product and its realtime trace capability is superb. But it is not a "true hardware-breakpoint debugger" as any attempt to set an execution breakpoint in the BIOS will prove. So it is not clear what it is that the reviewer had in mind when using ATRON as a yardstick.

The review claims that the debugger can break on register values. Perhaps this is so. But Intel's ICE cannot perform such a break, and given the rest of the article, my guess is that neither can the reviewed product.

I have avoided mentioning the product's name because it might be a useful tool. Bad arguments on the product's behalf cast doubts on any good qualities it might have, and they make me wonder about the rest of the magazine, as well.

Michael Liebert
North Caldwell, NJ

Periscope was chosen as the January Product of the Month because it represents what we felt was an excellent balance between power and cost and it has an extraordinarily clean and innovative design. Associate technical editor Dan Beale and I used Periscope for a period of several weeks, tracing idiosyncratic software such as Microsoft Windows, and the overall aura of quality was too strong to ignore. All Product of the Month candidates are tested in-house without the knowledge of the vendor, and the winner is not notified until the issue containing the column is published. (Also note that Periscope was

reviewed in detail in the March 1986 issue; see "Breaking Out With Periscope," Ward Christensen, p. 65.)

—JD

STICKING OUT HIS NEC

I would like to comment on Ted Mirecki's sidebar "V20 Compatibility and Performance" to the article "8088 vs V20" in the April 1986 issue (Juan Jimenez and Steve King, p. 73). I have an NEC V20 microprocessor installed in my PC compatible in place of the Intel 8088, and I have never had any compatibility problems. I also wrote my own set of Turbo Pascal benchmarks for the Intel 8088 versus the V20. My results for numeric calculations match those in the article, but I also ran two tests involving string manipulation.

The first test repeatedly concatenated five 51-byte strings to produce one 255-byte string; the second test repeatedly assigned one 255-byte string to another. The results from both of these tests indicated that the V20 is almost twice as fast as the 8088. It is possible that a similar instruction mix is used in the Norton SI program, which would account for the high performance rating.

David A. Hough
Littleton, CO

ERRATUM

With regard to information about communications links that appears on page 93 of "Controlling from Afar" (Augie Hansen, April 1986, p.84), please note the following corrections:

The maximum distance for unconditioned, unbalanced lines conforming to the RS-232 specification is 50 feet (about 15 meters), at a maximum data rate of 20 kilobits per second. The maximum distance may be extended beyond 50 feet by the use of special low-capacitance cabling or by reducing the data rate. As measured from the connection point at the data terminal equipment (DTE), the total equivalent load capacitance presented by the cabling and by the signal termination at the data communications equipment (DCE) or another DTE device must not exceed 2,500 picofarads.

To obtain reliable, direct connections over still longer distances and at high data rates, electronics and cabling should be used that conform to a balanced-circuit digital interface such as the RS-232 specification. In practice, distances of several miles are attainable under favorable conditions.

—CH

TECH PC TWIN MULTIUSER
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TECH PC/XT BASE UNIT WITH 640K, AND TWO 360K DISK DRIVES.

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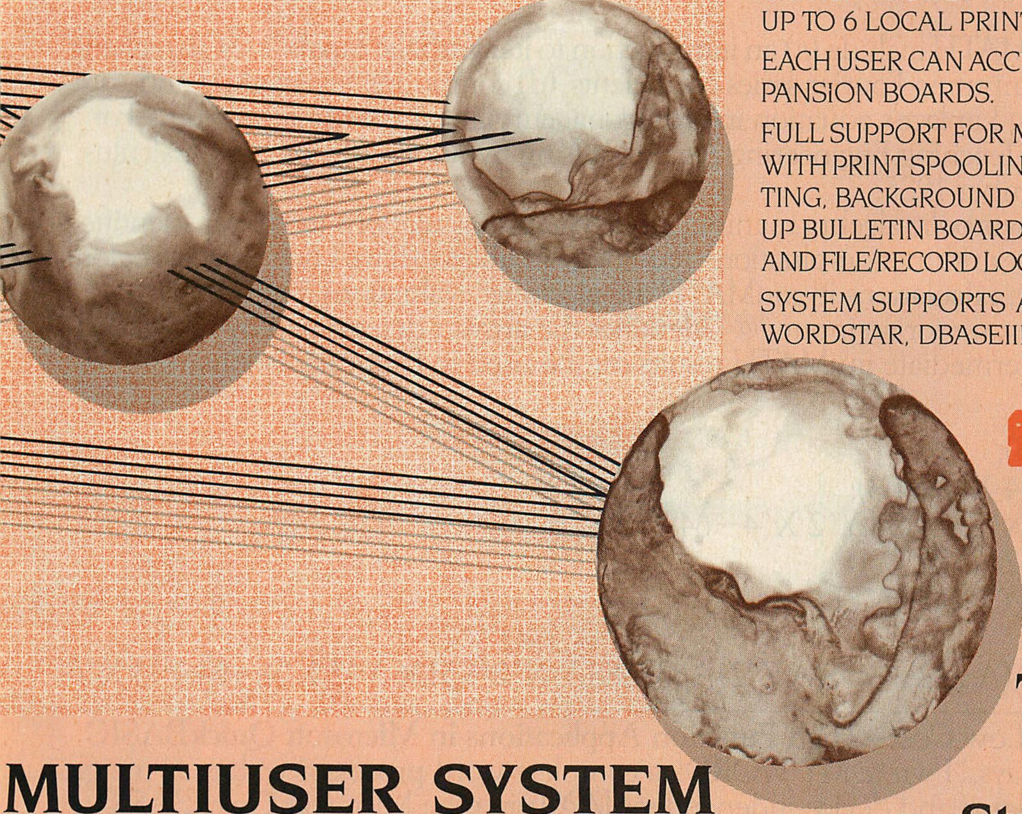
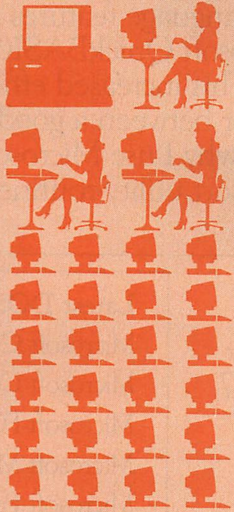
SYSTEM SUPPORTS ALL POPULAR SOFTWARE SUCH AS WORDSTAR, DBASEIII, LOTUS 123, MULTIMATE, ETC.



TECH PC TURBO QUAD MULTIUSER
Starting From $5999

MULTIUSER SYSTEM



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SYSTEM SUPPORTS ALL POPULAR SOFTWARE SUCH AS WORDSTAR, DBASEIII, LOTUS 123, MULTIMATE, ETC.

CHOICE

MAINTENANCE
MOHAWK DATA SCIENCES

MICROSOFT LANGUAGES NEWSLETTER Vol. 1, No. 7

News about the Microsoft Language Family

Microsoft® muMATH™ used as a tool for teaching college calculus

In the fall of 1985, Cornell University began using Microsoft muMATH in its sophomore level math course that is taught to over 500 students. Professor Richard H. Rand and his colleagues at Cornell have developed a series of computer lessons that introduce the students to the power of computer algebra. Dr. Rand says that without a powerful product like muMATH, "...the point of the problem can be lost in the detail of the solution." Microsoft muMATH makes it possible to ..."assign 'tough' homework problems and to reinforce and clarify the mathematical principles with practice on the computer."

The lessons involving muMATH include (a) an introduction to its symbolic capabilities, (b) solving differential equations, (c) computing Fourier series coefficients, (d) computing eigenvalues and eigenvectors, and (e) deriving Laplace's equation in orthogonal curvilinear coordinate systems. For additional information, see "Teaching Engineering Analysis Using Symbolic Algebra and Calculus," *Engineering Education*, November 1985.

Microsoft muMATH is a symbolic algebra manipulation system. Calculations in typical scientific and engineering languages are arithmetic evaluations, requiring variables to have known values before they can be used. In contrast, calculations in muMATH are algebraic evaluations, performed symbolically. "?" prompts the user for an input. "@" identifies the answer determined by muMATH. The example shows how intermediate muMATH results can be used in later calculations.

```
A> MUSIMP MATSOL
?  LOAD (CALCULUS);
?  E1:EXPAND ((107-4 X^2 Y)^3);
@: 1225043-137388 Y X^2+5136 Y^2 X^4-64 Y^3 X^6
?  E2: DIF (LN COS(A Z^2),Z);
@: -2 A Z SIN (A Z^2)/COS(A Z^2)
?  E1+E2;
@: 1225043-2 A Z SIN (A Z^2)/COS(A Z^2)-137388 Y X^2+5136 Y^2 X^4-64 Y^3 X^6
```

T.N.T. Software Develops Low Cost—High Function Applications in Microsoft QuickBASIC

Bruce Tonkin, president, says, "I wrote MY WORD!, a complete word processor with mail merge, macros, undelete, sort, calculator, and device-independent I/O, using the Microsoft QuickBASIC Compiler. I think Microsoft QuickBASIC is the best available language for any product needing dynamic character string operations. The new structured language features make for efficient, modular, and exceptionally readable code. Also, the Microsoft QuickBASIC Compiler takes advantage of the full capabilities of the latest versions of DOS. This increased efficiency can make the difference between a mediocre product and a good one, or between a good product and an outstanding one. I want to sell the best software I can. That's why I use Microsoft QuickBASIC."

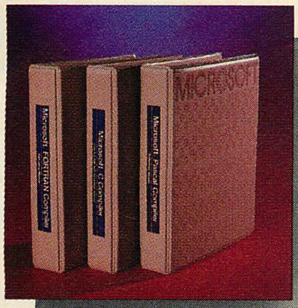
T.N.T. Software also distributes a spelling checker and sort utility routines written in Microsoft QuickBASIC. Source code is available.

For more information on the products and features discussed in the Newsletter,
write to: Microsoft Languages Newsletter
16011 NE 36th Way, Box 97017, Redmond, WA 98073-9717
Or phone:
(800) 426-9400. In Washington State and Alaska, call (206) 882-8088. In Canada, call (416) 673-7638.

Latest DOS Versions:

Microsoft C Compiler	3.00
Microsoft COBOL	2.10
Microsoft FORTRAN	3.31
Microsoft Macro Assembler	4.00
Microsoft Pascal	3.31
Microsoft QuickBASIC	1.02

Look for the Microsoft Languages Newsletter every month in this publication.



Language Integration

Microsoft has developed methods that allow one language to call subprograms from another alien language.

FORTRAN programmers are getting scarce these days.

The brightest computer science graduates are choosing to work in C, and many others are lining up behind COBOL. FORTRAN code seems best supported by rewriting old FORTRAN into C or Pascal. This task, however, requires a person fluent in *both* of the languages involved.

The problem cries out for a means of preserving stable, shaken-out code in its original language and calling it from the language being used in development. The fundamental stumbling block to this process is that low-level calling conventions usually are not defined in high-level language standards. Two vendors can produce standard versions of the same language without providing the ability for one implementation to call subprograms in the other.

The situation is not hopeless. Perhaps a vendor of several languages could create a rational low-level calling convention understandable by each language, thereby making code in one language callable from all the others. Two vendors are moving in this direction: Microsoft with its latest releases of C, FORTRAN, and Pascal for DOS; and Pecan Software Systems with UCSD Pascal, UCSD FORTRAN, and UCSD BASIC running under Pecan's DOS-based p-System. Both vendors offer solid products, but Microsoft has addressed more of today's professional developer audience by including a C compiler in its product. For this reason, *PC Tech Journal* has named Microsoft's method of high-level language integration Product of the Month for July 1986.

Even when dealing only with languages under the control of a single vendor, the problem of language integration still exists. The question of the 8086 memory model used by a language must be considered. Calling across memory model boundaries is impossible because of the assumptions made by the caller and the subprogram that is called about the nature of the code and data addresses involved. Microsoft C supports the small, medium, and large memory models, but, until recently, Microsoft Pascal supported only the medium model and FORTRAN only the large model. Pascal's memory model, however, was changed to large in release 3.3, so the three languages now can link using the large model.

Far more difficult is the question of calling conventions. FORTRAN and Pascal push parameters onto the stack in the order that they appear in subprogram declaration. C places parameters on the stack in reverse order. This allows a C subprogram to have a varying number of parameters because the first parameter declared is the last one on the stack and always at the same offset from the stack frame's base pointer. In FORTRAN and Pascal, the subprogram removes the parameters and return address from the stack as it returns; in C the calling logic cleans up the stack after a subprogram returns.

Microsoft has built attribute key words into the three languages. This feature allows all of them to use either the C or the FORTRAN/Pascal calling convention on a declaration-by-declaration basis. This control is available for both external (imported) and public (exported) subprograms.

The most difficult consideration in calling subprograms across language boundaries is parameter passing. Microsoft has given its three languages the ability to pass parameters either by value (pushing a copy of the data item passed onto the stack) or by reference with a long or short address. This involves extending FORTRAN with VALUE and NEAR attributes for parameters (the default has been to pass by reference with a long address) and extending Pascal with the VARS reserved word for declaring a reference parameter with a long address.

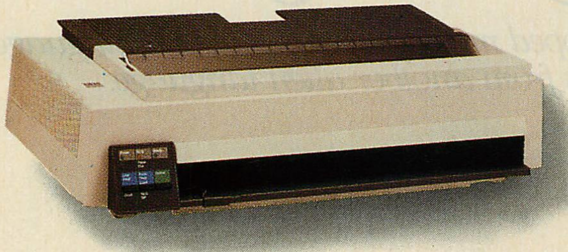
The final question to be answered when attempting language integration is the interpretation of data passed as parameters across language boundaries. C automatically converts single-byte parameters (such as Pascal's Char and Boolean types) to two-byte integer types before passing by value; Pascal and FORTRAN code must anticipate this conversion. Microsoft provides several options and ample documentation. Real number values are encoded differently depending on precision and language, and transferring real values across language bounds demands that much attention be given to detail.

Microsoft has provided an appendix entitled "Mixed Language Programming" with the documentation. Half of the 41 pages of this appendix is devoted to mixed-language programming considerations; the remaining half is a matrix that details how each major type from each language can be transferred to other languages. Only FORTRAN's large arrays (those that exceed 64KB) cannot be used by C or Pascal code.

Microsoft has not yet commented on whether it will incorporate its BASIC compiler into language integration. The prospects for COBOL and LISP are not good, because they are both interpreters. Nonetheless, the seamless integration of two languages as alien as C and FORTRAN is a major achievement and bodes well for the continuing struggle to advance software technology without losing the investment already made in past development.

High-Level Language Integration
Microsoft C, 3.0: $395
Microsoft FORTRAN, 3.31: $350
Microsoft Pascal, 3.31: $300
Microsoft Corporation
16011 N.E. 36th Way
Redmond, WA 98052-6399
800/426-9400; in Washington, 206/882-8088
CIRCLE 336 ON READER SERVICE CARD

Hardware, software, and other developments for the IBM PC family



IBM Proprinter XL

DOS version 3.2

FROM IBM

A wide-carriage model of the desktop IBM Proprinter has been announced by **IBM**. The all-points-addressable **Proprinter XL** features a three-button operator panel that lets users change print quality, choose character sizes and spacing, and print drafts in a quiet mode in 10 characters per inch. This nine-wire dot-matrix printer accommodates cut sheets or multipart forms up to 16½ inches wide and continuous forms up to 15 inches wide. $799.

Enhancements to the **IBM Token-Ring Network** enable users to share the resources of a wider range of information processing equipment and extend the distances over which networks can operate. PC users on the Token-Ring Network can access System/370 host applications through the 3725 communications controller directly attached to the network. As many as eight Token-Ring Networks can be connected to host systems through a single controller. System/36 computers can attach to the Token-Ring Network via a dedicated PC/AT operating as a LAN communications controller using the 5360 and 5362 LAN attachment feature. The 8219 optical fiber repeater extends the reach of the network to 2 kilometers (6,600 feet). The 8218 copper repeater extends the distance between wiring closets in a building to 750 meters (2,500 feet). The new IBM Type 9 media specification, introduced for the IBM Cabling System, is a thinner, more flexible version of Type 1 plenum cable.

IBM Series/1 Office Connect is a licensed program that enables Series/1 computers to distribute documents created on PCs. Documents may be stored on Series/1 direct access storage devices and printed on IBM 5219 letter-quality printers. This program offers electronic mail and messaging capabilities to PC users connected via the Series/1 to IBM System/370 hosts, System/36 and System/38 computers, and other IBM and non-IBM systems. $6,600.
IBM Corporation, Information Systems Group, 900 King Street, Rye Brook, NY 10573; Contact the local IBM dealer, 800/426-2468
CIRCLE 301 ON READER SERVICE CARD

IBM also has announced **DOS version 3.2** as well as upgrades to four products that act as extensions to the operating system. **IBM TopView version 1.1** lets the user run several applications at the same time and switch among them easily. New functions include the ability to increase the number of programs users can start by allowing them to swap programs to disk or extended memory, the ability to process batch files, support for COMMAND.COM, resource management for up to five printers, and coexistence with all other system extensions. DOS 3.2, $95; TopView 1.1, $175.

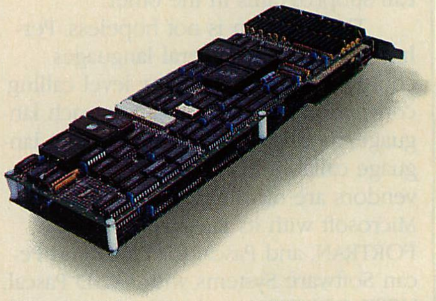
The **IBM PC LAN Program version 1.1** permits the connection of two or more PCs, PC/XTs, PC/ATs, or PC Portables on the Token-Ring Network and PC Network. The upgraded program features the ability to use an IBM PC LAN server as an IBM 3270 emulation gateway, increased message editor functions, support for the Token-Ring adapter and the NETBIOS program for the Token-Ring adapter, and coexistence with all other system extensions. $125.

IBM PC 3270 Emulation Program version 2.0, which allows PCs to communicate with a host computer, features an optional 3278/79 adapter or SDLC adapter attachment and coexistence with all other system extensions. $425; entry-level version, $185.

Finally, the **IBM Graphics Development Toolkit version 1.1** contains the virtual device interface that allows device-independent software and device-dependent drivers to communicate. New functions of version 1.1 include raster, bit map, and clipping; mouse support; and coexistence with all other system extensions. $495.
IBM Corporation, P.O. Box 1328, Boca Raton, FL 33429-1328; Contact the local IBM dealer, 800/426-2468
CIRCLE 302 ON READER SERVICE CARD

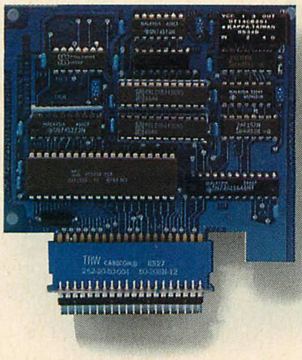
HARDWARE

Verticom Inc. has announced a 1,024-by-768 high-resolution controller called the **H-16**. The board emulates the IBM Enhanced Graphics Adapter, Color Graphics Adapter, and Monochrome Display Adapter and features more than 1.3MB of display memory. This memory is partitioned into two buffers for instantaneous double buffering, which allows the user to view and pan an entire object as well as a zoomed-up portion of that object at the same time in a split-screen format. The H-16 offers 16 displayable colors from a palette of 4,096 with four independently addressable bit planes. Under $2,995.
Verticom Inc., 545 Weddell Drive, Sunnyvale, CA 94089; 408/747-1222
CIRCLE 309 ON READER SERVICE CARD

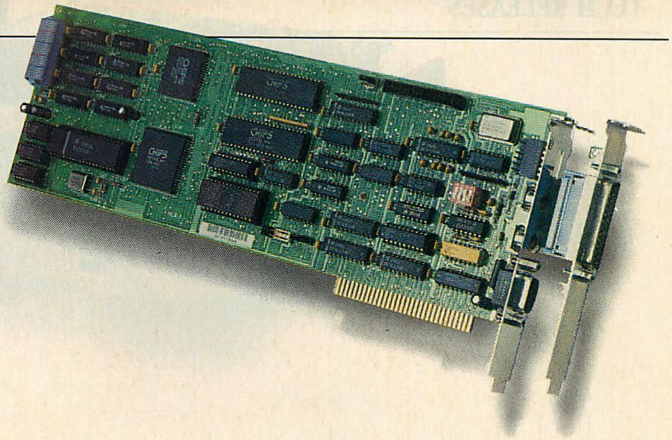


Verticom's H-16 high-resolution controller

Quadram has announced **QuadEMS+**, a PC/XT expanded-memory board that is 100-percent software switchable between the AST/Quadram/Ashton-Tate enhanced expanded memory specification (AQA/EEMS) and the Lotus/Intel/Microsoft expanded memory specification



SURPRISE! by Maynard Electronics



Tecmar's EGA Master

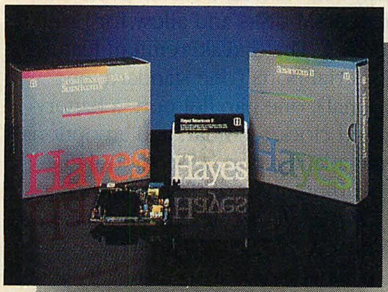
(LIM/EMS). The QuadEMS+ supports 64KB and 256KB chips on the same board and can be stacked with 2MB of addressable memory. The board is also available in a multifunction version called the **QuadEMS+ I/O**, which features one bidirectional parallel port, one serial port that offers users a choice of 12 addresses, and a realtime clock/calendar with a battery backup. QuadEMS+ with 256KB, $495; QuadEMS+ I/O with 256KB, $545.
Quadram, One Quad Way, Norcross, GA 30093-2919; 404/923-6666
CIRCLE 304 ON READER SERVICE CARD

SURPRISE!, a high-speed board from **Maynard Electronics**, does not use an expansion slot. It is installed into the 8088 slot of a system's motherboard to accelerate the PC by up to 2½ times the normal speed. The user can toggle SURPRISE! between fast and slow operation by pressing the Ctrl-Alt-\ combination. The software included with the board accelerates the speed of DOS. $249.
Maynard Electronics, 460 E. Semoran Blvd., Casselberry, FL 32707; 305/331-6402
CIRCLE 303 ON READER SERVICE CARD

A high-resolution controller card for color or monochrome graphics and text displays that is compatible with IBM's Enhanced Graphics Adapter has been announced by **Tecmar, Inc.** The **EGA Master** provides 640-by-350 resolution text and graphics in 16 colors (from a palette of 64), using the IBM Enhanced Color Display. It allows smooth scrolling and panning, and permits the production of 1,024 programmable characters. An optional serial port can be added to the board. $395.

Tecmar also has introduced the **5251/11 Emulator Board**, a hardware/software package that enables a PC, PC/XT, or PC/AT to communicate with IBM System/3x series computers. This permits the simultaneous running of host, printer, and PC sessions at full speed. Fully IBM compatible, Tecmar's 5251/11 Emulator Board operates with standard IBM software running on the host. The board fits into the half slot on the XT or PC Portable and incorporates surface-mount technology, custom gate arrays, and hybrid drivers for higher system reliability. $795.
Tecmar, Inc., 6225 Cochran Road, Solon, OH 44139-3377; 216/349-0600
CIRCLE 305 ON READER SERVICE CARD

A new version of the **Smartmodem 1200B** internal modem from **Hayes Microcomputer Products, Inc.** works



A new version of the Smartmodem 1200B

in full- and half-card slots. Features include call progress monitoring, rotary and 16 DTMF or PABX dialing commands, built-in test modes, full Hayes AT command set implementation, CCITT V.22 compatibility, voice/data transmission, two phone jacks, 1200-bps and 0-to-300 bps transmission, and convenient redialing. The modem is bundled with Smartcom II software. $549.
Hayes Microcomputer Products, Inc., P.O. Box 105203, Atlanta, GA 30348; 404/441-1617
CIRCLE 307 ON READER SERVICE CARD

A 2400-bps, autodial, half-card modem has been announced by **Anchor Automation, Inc.** The newest member of Anchor's Signalman family of modems, the LIGHTNINGi operates asynchronously at 2400 bps with an automatic equalizer to ensure clear transmission over most telephone lines and with fallback to 1200 or 300 bps. It is bundled with Norton-Lambert's LYNC communications software. The modem includes an on-board speaker that provides audible call progress information. $499.
Anchor Automation, Inc., 6913 Valjean Avenue, Van Nuys, CA 91406; 818/997-7758
CIRCLE 308 ON READER SERVICE CARD

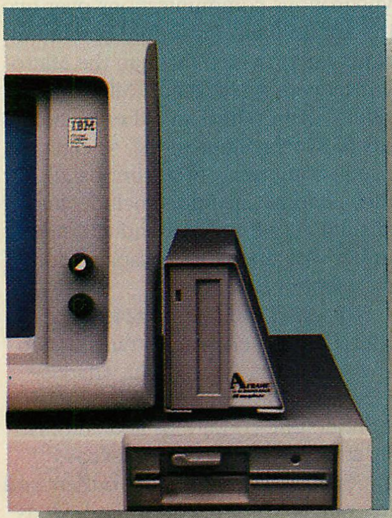
May-Craft Information Systems, Inc. has announced the availability of **Microcom's AX** line of asynchronous error-checking modems—five modems with transmission speeds up to 19.2 bps. All the modems provide Hayes (AT) and Microcom command set compatibility. New technology (including data compression) allows high-speed, error-free asynchronous communications over two wire dial-up lines. Error-free communications are provided through the Microcom Networking Protocol (MNP). All AX modems can operate in either asynchronous or synchronous mode, selected through commands or a front panel switch. Standard features include auto-dial, auto-answer, repeat and alternate number dial, and storage capacity for nine telephone numbers.

The **AX/1200** and **AX/2400** use MNP class 4 for error-free transmission with higher data throughput. Adaptive packet assembly transparently monitors telephone line conditions and automatically adjusts data packet size accordingly. Specially designed I/O buffers and flow control allow operation as high as 9600 bps even though the AX modem is transmitting at only 1200 or 2400 bps. The **AX/2400c** uses MNP class 5, which includes a proprietary compression technique that encodes data and reduces the number of bits transmitted, allowing text files to be sent over ordinary telephone lines at speeds as high as 4800 bps. The **AX/9612c** and **AX/**

AT-4000-i by Acknowledge

9624c use MNP class 6, which, in addition to the techniques in classes 4 and 5, provides statistical duplexing. This enables the modems to allocate line bandwidth and data traffic to achieve maximum throughput in both interactive use and file transfer. AX/1200, $495; AX/2400, $749; AX/2400c, $899; AX/9612c, $1,599; AX/9624c, $1,795.
May-Craft Information Systems, Inc., 4312 Beltwood Parkway S, Dallas, TX 75244; 800/527-7456; in Texas, 214/392-3766
CIRCLE 306 ON READER SERVICE CARD

Two high-capacity cartridge tape backup systems for the PC/XT and PC/AT have been announced by **Acknowledge, Inc.** Based on 3½-inch tape drive technology, the products provide 40MB of data storage per cartridge; data transfer rates exceed 3MB per minute. **Model**


A-Frame-40 by Acknowledge

AT-4000-i is an internally mounted unit that is designed specifically for the AT. **A-Frame-40** is an external system that fits on top of a system's CPU box just to the right of the monitor; thus, it takes up no desk space. AT-4000-i, $595; A-Frame-40, $850; optional FCAB01 floppy-disk controller board, $195.
Acknowledge, Inc., 100 Pennsylvania Avenue, Framingham, MA 01701; 800/533-1776; in MA, 617/620-8843
CIRCLE 320 ON READER SERVICE CARD

AST Research, Inc. introduced the **SixPakPremium** expanded memory/multifunction board for the new PC/XT as well as the existing PC/XT, PC, and compatibles. SixPakPremium operates under the AST enhanced expanded memory specification. The board comes bundled with DESQview multitasking/windowing software and AST's SuperPak utility software. As a result, users can create RAM disks and allow for print spooling. The SixPakPremium features two serial ports (one standard, one optional), one parallel port, a battery-backed clock/calendar, and an optional game adapter port. $595 to $1,445, depending upon configuration.
AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714; 714/863-1333
CIRCLE 310 ON READER SERVICE CARD

A high-performance multifunction board for use with the PC/AT that offers expanded, extended, and conventional memory, as well as two serial ports and one parallel port has been announced by **IDEAssociates, Inc.** The **IDEA Supermax/EMS** provides a memory capacity of up to 4MB and is compatible with the Lotus/Intel/Microsoft expanded memory specification. $495 to $2,595, depending upon configuration.
IDEAssociates, Inc., 29 Dunham Road, Billerica, MA 01821; 617/663-6878
CIRCLE 314 ON READER SERVICE CARD

A multifunction, multidisplay board called MEMEK has been announced by **Boca Research, Inc.** MEMEK offers up to 2MB of expanded memory designed to conform to the Lotus/Intel/Microsoft specification. The board also provides a parallel port, a serial port, a clock/calendar, and emulation of the Hercules Graphics and Plantronics color cards as well as the IBM CGA and MDA. MEMEK installation requires neither switch nor jumper settings. The product is shipped with a RAM disk and a print spooler. $645; with 1MB RAM, $795; additional 1MB RAM expansion board, $345.
Boca Research, Inc., 6401 Congress Avenue, Boca Raton, FL 33431; 305/997-6227
CIRCLE 313 ON READER SERVICE CARD

Philips Subsystems and Peripherals, Inc. has introduced a CD ROM drive with a fully implemented SCSI interface. The **CM 110** drive provides fast and


CM 110 CD-ROM by Philips Subsystems and Peripherals

virtually error-free access to 600MB of digitally encoded data on standard 120-mm (4.72-inch) compact disks. The SCSI interface board handles both error detection and correction and allows for streaming capabilities so as to maintain a data transfer rate of 150K bps. $600 in OEM quantities.
Philips Subsystems and Peripherals, Inc., 100 E. 42nd Street, New York, NY 10017; 212/850-5011
CIRCLE 319 ON READER SERVICE CARD

Turbo Pascal and the Turbo Pascal family give you a perfectly integrated programming environment and unbeatable speed, power, and price

> "Language deal of the century . . . Turbo Pascal
>
> *Jeff Duntemann, PC Magazine*
>
> Turbo Pascal has got to be the best value in languages on the market today
>
> *Jerry Pournelle, BYTE Magazine*
>
> This compiler, produced by Borland International, is one of the best programming tools presently available for the PC
>
> *Michael Covington, PC Tech Journal*"

Turbo Pascal® is *faster* than any other Pascal compiler, and at only $69.95, a distinctly better deal. But it offers much more than speed, power, and price.

There's also the complete Pascal family of products that's grown from 1 to 9 products in just 3 years.

- Turbo Pascal 3.0
- Turbo Pascal with the 8087 support
- Turbo Pascal with Binary Coded Decimal, (BCD)
- Turbo Pascal with 8087 and BCD
- Turbo Database Toolbox™
- Turbo Graphix Toolbox™
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- Turbo Editor Toolbox
- Turbo GameWorks

Turbo Pascal is backed by a complete range of "toolboxes" that give you most of the programming tools you'll ever need.

The Turbo Pascal family is never static, but is continuously expanding, with new products like Turbo Editor Toolbox™ and Turbo Gameworks.™

The secret of software success is not merely low price, but top quality, allied with complete documentation, like our 400-page reference manual.

All of which are some of the reasons why Turbo Pascal is clearly the leader, and the recipient of awards like PC Week's **"Product of the Year"** and PC Magazine's **"Award for Technical Excellence."** And some of the reasons why Turbo Pascal has now become a *de facto* worldwide standard with more than half a million users.

Turbo Pascal has grown from a single product 3 years ago to a family of 9 today.

Success breeds success, so the Turbo Pascal family has flourished. Your choices now include:

☐ **Turbo Pascal 3.0** combines the fastest Pascal compiler with an integrated development environment.

☐ **Turbo Pascal with 8087** math co-processor support for heavy duty number-crunching, and/or **Binary Coded Decimals** to eliminate rounding-off errors for business applications.

☐ **Turbo Database Toolbox** is a perfect complement to Turbo Pascal. It includes a complete library of Pascal procedures that allows you to search and sort data, and build powerful database applications.

☐ **Turbo Graphix Toolbox** includes a library of graphics routines for Turbo Pascal programs. Lets even beginning programmers create high-resolution graphics with an IBM,® Hercules,™ or compatible graphics adapter. Does complex business graphics, easy windowing, and stores screen images to memory.

☐ **Turbo Tutor** teaches you step by step how to use Turbo Pascal, with commented source code for all program examples on diskette.

Save $109.70 when you choose the Turbo Jumbo Pack. 6 different Turbo Pascal products for only $245.00!

For only $245.00, you get Turbo Pascal 3.0 *and* Turbo Editor Toolbox *and* Turbo Tutor *and* Turbo Graphix Toolbox *and* Turbo GameWorks *and* Turbo Database Toolbox!

All 6 for only $245.00, which saves you $109.70. This limited offer is good through September 1, 1986, so act now.

NEW! *Amazing value! Turbo Editor Toolbox includes MicroStar,™ a full-blown editor that also does windows!* **Turbo Editor Toolbox** not only gives you ready-to-compile source code and a 200-page manual that tells you how to integrate the editor procedures and functions into your programs, but also includes MicroStar, a complete editor with full windowing capabilities. (You could pay $100.00 or more for a program like MicroStar, but you get it free as part of our Turbo Editor Toolbox.) You can also use Turbo Editor (which of course integrates with Turbo Lightning™) to build your own word processor!

NEW! *Turbo GameWorks gives you the games you can write, rewrite, bend and amend!* **Turbo GameWorks** reveals the secrets of game design and the strategies. You're given source code, a 200-page manual, and the insight needed to write and customize your own irresistible games.

Turbo GameWorks also includes ready-to-play Chess, Bridge, and Go-Moku—an ancient Japanese game that can divert you from reality for hours on end.

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in CA call (800) 742-1133

Copies	Product	Price	Totals
___	Turbo Pascal 3.0	$69.95	$ ______
___	Turbo Pascal w/8087††	$109.90	$ ______
___	Turbo Pascal w/BCD††	$109.90	$ ______
___	Turbo Pascal w/8087, BCD††	$124.95	$ ______
___	Turbo Database Toolbox	$54.95	$ ______
___	Turbo Graphix Toolbox†	$54.95	$ ______
___	Turbo Tutor	$34.95	$ ______
___	Turbo Editor Toolbox†	$69.95	$ ______
___	Turbo GameWorks†	$69.95	$ ______
___	Turbo Jumbo Pack†	*$245.00	$ ______
	Outside USA add $10 per copy CA and MA res. add sales tax		$ ______
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I use: ___ PC-DOS ___ MS-DOS ___ CP/M-80 ___ CP/M-86

My computer's name and model is: ______________________

The disk size I use is: ☐ 3½" ☐ 5¼" ☐ 8"

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**Limited Time Offer until September 1, 1986.*

***YES, if within 60 days of purchase this product does not perform in accordance with our claims, call our customer service department and we will gladly arrange a refund.*

Minimum System Requirements:
Turbo GameWorks, Turbo Graphix Toolbox, & Turbo Editor Toolbox—192K. All other products, 128K.
†IBM PC, PCjr, AT, XT, and true compatibles.
††16-bit only.

TF6

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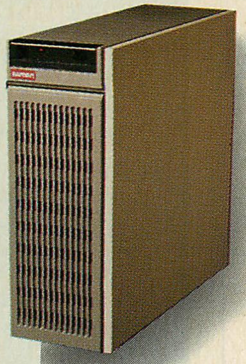
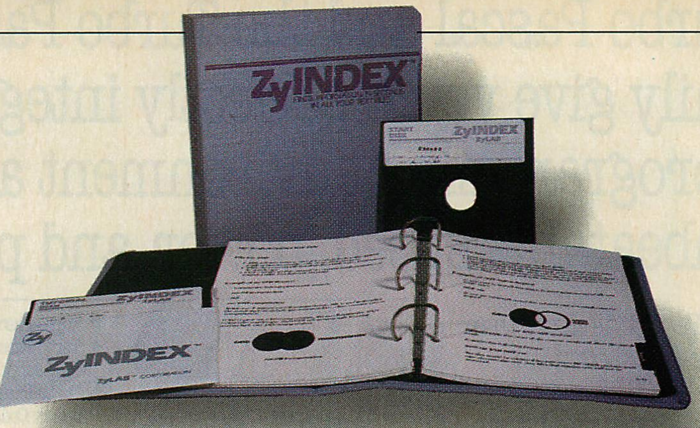
CIRCLE NO. 253 ON READER SERVICE CARD



Banyan's Network Server



By ZyLAB Corporation

Chauffeur HT, a video display adapter from **STB Systems, Inc.**, combines three industry standards: STB's Chauffeur technology (which displays standard CGA software on IBM-compatible monochrome monitors without any drivers), Hercules monochrome graphics, and Tseng Laboratories 132-character compatibility. No preboot software or special drivers are needed to use the Chauffeur HT with standard CGA or MGA software. For monochrome monitors, the adapter converts color display to 16 shades of gray, and text is displayed in high-resolution 8-by-14 characters. Hercules-compatible software is displayed in 720-by-348 resolution. The Chauffeur HT runs all CGA and monochrome/printer adapter software on standard RGB color monitors. Software compatible with the STB Graphix Plus II and Color XVI display adapters can use the Chauffeur HT's high-resolution 4- and 16-color graphics modes. The Chauffeur HT drives high-resolution 25-KHz color monitors producing 400-line displays. $349.
STB Systems, Inc., 601 N. Glenville, Suite 125, Richardson, TX 75081; 214/234-8750
CIRCLE 311 ON READER SERVICE CARD

Three modem products have been introduced by **Codex Corporation**. The V.32 modems, **Codex 2250** and **2260**, allow 4800- and 9600-bps full-duplex data transmission over dial lines. The modems exceed recommendations established by the CCITT for V.32 high-speed dial-line transmission and provide synchronous and asynchronous communications, full ACU support, short and long haul echo cancellation, and a coded modulation scheme. The **Codex 2650** is a high-speed multipoint modem that operates at 14.4K bps, achieving 99.9 percent error-free performance. It operates at a significantly higher speed than 9600 bps without compromising data integrity. The **Codex 2321** and **2341** economy modems are designed for multipoint network operation and offer competitive performance for 4800- and 9600-bps transmission over leased lines. Codex 2250, $2,995; 2260, $3,495; 2650, $6,600; 2321, $1,500; 2341, $1,950.
Codex Corporation, 20 Cabot Blvd., Mansfield, MA 02048-1193; 617/364-2000
CIRCLE 318 ON READER SERVICE CARD

A new EGA-compatible monitor has been announced by **Quadram**. The **Quadchrome Enhanced Display** provides 640-by-320 pixel resolution with an IBM Enhanced Graphics Adapter (EGA). It also provides a 320-by-200 resolution Color Graphics Adapter (CGA) mode display and is equipped to switch automatically between EGA (22.0 KHz) and CGA (15.75 KHz) modes. The Quadchrome display has a switch that can be set to green and amber text to provide crisp monochrome output. It features a 13-inch, nonglare, tinted screen and an 80-character-by-25-line display with a sharp .31-mm trio dot pitch. The screen can support up to an 80-character-by-43-line display. $795.
Quadram, One Quad Way, Norcross, GA 30093; 404/923-6666
CIRCLE 312 ON READER SERVICE CARD

SOFTWARE

DOS 3.1 and NetBIOS support are included in release 1.3 of **VINES**, a virtual networking software package from **Banyan Systems Incorporated** (which also produces a Network Server). This release includes design tools that enable programmers to develop network applications; diagnostics that operate locally or remotely for system hardware, network media, and serial communications; support for the Ungermann-Bass baseband/broadband Net/One LAN; and Interactive Systems/3M broadband LAN. Also included are timed system backup and recovery; configurable 25th line display; improved print spooling, forms support, print queue management, and printer access control.
Banyan Systems Incorporated, 135 Flanders Road, Westboro, MA 01581; 617/898-2404
CIRCLE 323 ON READER SERVICE CARD

A new release of its full-text search software has been announced by **ZyLAB Corporation**. **ZyINDEX 2** is compatible with CD ROM devices, write-once-read-many (WORM) optical disks, popular LANs, and 26 major word processors. ZyINDEX can search text stored on CD ROMs and WORMs, enabling users to find any string in a 20MB section of the disk in seconds. Users can mark searched text for automatic saving and can retrieve updates stored on a hard disk. Features of the new release include simplified menus, color support, the removal of copy protection and configuration files, and a rewritten user's guide and tutorial. Standard $145; Professional version, $295; Plus version, $695; tutorial disks, $10; upgrade, $35.
ZyLAB Corporation, 233 E. Erie Street, Chicago, IL 60611; 312/642-2201
CIRCLE 324 ON READER SERVICE CARD

Storage Dimensions, Inc. has announced the availability of **SpeedStor**, a disk drive integration software package. SpeedStor breaks the DOS 32MB barrier and easily integrates from 20MB to 256MB of internal hard-disk mass storage in the PC/AT. It provides up to a 30 percent improvement in hard disk data throughput and system performance. The product features easy-to-learn menu-driven programs, as well as a formatter, diagnostics, and a partition editor. It is fully compatible with DOS and DOS 3.1 LANs. $149.
Storage Dimensions, Inc. 14127 Capri Drive, Suite 1, Los Gatos, CA 95030; 408/370-3304
CIRCLE 325 ON READER SERVICE CARD

Reflex, The Analyst upgrades and adds the new Reflex Workshop!

Why running your business without Borland's Reflex and the new Reflex Workshop is an act of blind faith

Running a successful business isn't something you can do with your eyes shut, but no matter what business you're in, Reflex™ and the new Reflex Workshop™ give you all the tools and views to see what all the numbers look like.

Using Lotus 1-2-3® or dBASE® without Reflex is like driving at night without lights

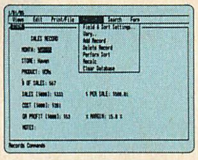
Products such as 1-2-3 or dBASE can do the numbers for you, but you may still not get the picture—simply because they can't show you analytical graphs and pictures of your data, nor can they analyze and summarize all the information you manipulate like Reflex can.

The best just got better. Introducing Reflex 1.1 NEW!

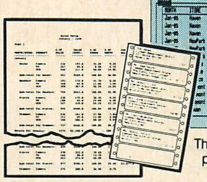
The new Reflex 1.1 with extended memory support allows you to manage huge databases of up to 8 megabytes of RAM, 32,000 records, and 250 fields per record with the now-legendary "Reflex Lightning Speed."

Furthermore, Reflex 1.1 with its EGA support displays 40 lines of information in its spreadsheet-style List View, compared to less than 25 lines displayed by traditional spreadsheets.

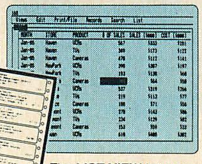
Reflex gives you five graphic ways of looking at your data, five different ways of analyzing your information.



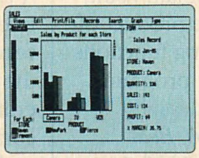
The **FORM VIEW** lets you build and examine your database.



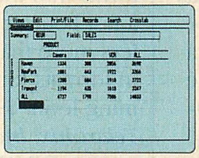
The **REPORT VIEW** allows you to generate everything from mailing labels to sophisticated reports. You can use database files created with Reflex or transferred from 1-2-3, dBASE, PFS: FILE, and other applications.



The **LIST VIEW** lets you put data in tabular list form just like a spreadsheet.



The **GRAPH VIEW** gives you instant interactive graphic representations.



The **CROSSTAB VIEW** gives you amazing "cross-referenced" pictures of the links and relationships hidden in your data.

SPECIAL OFFER!

If you already bought Reflex 1.0, get Reflex 1.1 and the Reflex Workshop for only $59.95

Because you bought Reflex from us, you're "our kind of people." And since we're not the "take-the-money-and-run" kind of company, you can upgrade to Reflex 1.1 and the Reflex Workshop for only $59.95. If you prefer to simply upgrade to Reflex 1.1, you can do that for only $10.

SPECIAL OFFER!

*You get Reflex 1.1 and the Reflex Workshop for only $199.95**

Sold separately, the new Reflex Workshop is $69.95 and Reflex is $149.95, totaling $219.90—but you can get them both for a limited time only, at an amazing $199.95. So act now, rush to your nearest dealer, call us, or clip the coupon and put Reflex 1.1 and the Reflex Workshop to work for you right away!

NEW! Introducing the Reflex Workshop

Only $69.95

A major addition to Reflex, the new Reflex Workshop gives you a wide range of analytical tools written for specific applications. You can use these tools "as is" or modify them to suit your analytical and business needs. What you have to work with right away are 25 different tools:

For Finance/Accounting:
- Business Expense Tracking
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- Accounts Receivable Tracking & Aging Analysis
- Purchase Order Entry & Analysis
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- Leasing Inventory Management
- Asset Inventory Tracking
- Cash Management Trial Balance

For Administration:
- Membership Dues Tracking and Analysis
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- Time Management
- Appointment Scheduling
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- Facilities Planning

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- Sales Lead Tracking & Analysis
- Store Check Inventory Analysis
- Sales Analysis
- Trend Analysis
- Research Questionnaire Analysis

For Production and Operations:
- Manufacturing Quality Assurance Tracking
- Assembly Repair Turnaround Tracking
- Commercial Real Estate Tracking & Analysis
- Project Scheduling
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"The best database around . . . at any price.
Jean Lockwood, Computer Retail News

Everyone agrees that Reflex is the best-looking database they've ever seen.
Adam B. Green, InfoWorld

Reflex excels as an analytical tool . . . this program can become everyman's database manager.
Frank J. Derfler, PC Magazine

Borland has done it again.
Sheldon L. Richman, Washington Post"

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(you must return your disks)
Outside USA add $10 per copy
CA and MA res. add sales tax $ ____
Amount enclosed $ ____
Prices include shipping to all U.S. cities
†You must have an IBM or true compatible running DOS 2.0 or later.
My computer's name and model is: ____
The disk size I use is: ☐ 3½" ☐ 5¼"
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**Limited time offer until September 1, 1986*

***YES, if within 60 days of purchase this product does not perform in accordance with our claims, call our customer service department and we will gladly arrange a refund.*

†Minimum System Requirements:
384K—Runs on IBM PC, AT, XT, and true compatibles. IBM Color Graphics Adapter, Hercules Monochrome Graphics Card or equivalent.

Reflex works with Intel's Above Board AT and Above Board/PC, AST's RAMpage! and RAMpage! AT, Quadram's Liberty-PC and Liberty-AT, Tecmar's 640 Plus, IBM's EGA and 3270/PC, AT&T's 6300, and many others.

R6

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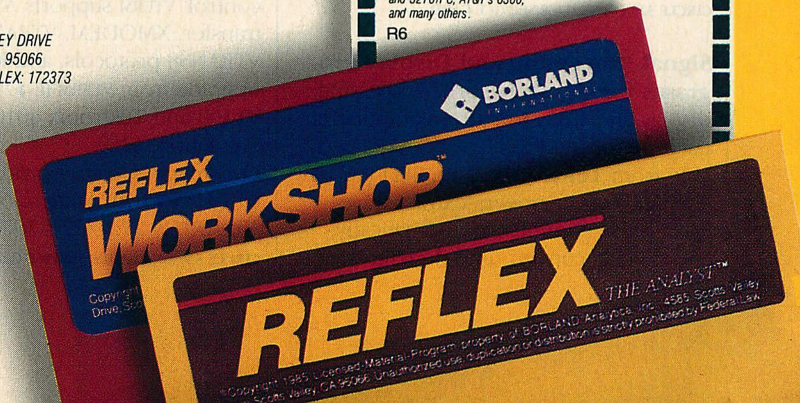


CIRCLE NO. 254 ON READER SERVICE CARD

From Allen, Emerson & Franklin, Inc.

Chalcedony's disk directory utility

Allen, Emerson & Franklin, Inc. has announced **version 2** of the **GTP Development System**. GTP is an application generator that produces error-free Turbo Pascal code for screen and database systems. Version 2 features the ability to create multiple-screen applications automatically, a context-sensitive help function, a new database manager, and global search criteria. $150.

Also available is the **GTP Professional Model**, which includes two fully integrated generators: a report generator operating from the database definitions created for screen programs; and a menu generator for bundling application programs together. $200.
Allen, Emerson & Franklin, Inc., P.O. Box 928, Katy, TX 77492; 713/391-8570
CIRCLE 327 ON READER SERVICE CARD

A disk directory utility from **Chalcedony Software** is designed to help the user move easily through DOS and printer commands. **SCOUT** is memory resident and can be unloaded when not in use. It can move files, perform mass file copy and delete, search for files, establish default sort, perform multiple file sorts, change sort type dynamically, display directories, alter file attributes, view text files, and tag, untag, and retag files. SCOUT can format a floppy disk from within a resident program at twice the speed of DOS. $49.95.
Chalcedony Software, 5580 La Jolla Blvd., Suite 126, La Jolla, CA 92037; 800/621-0852, ext. 468; in California, 619/483-8513
CIRCLE 328 ON READER SERVICE CARD

Signal Processing and Display Programs (SPD), a waveform processing, display and data structure manipulation package for the PC/XT or PC/AT, is available from **Tektronix, Inc.** SPD lets design and test engineers extract waveform pulse parameters automatically, and quickly convert time domain waveforms into the frequency domain using a fast Fourier transform. The product offers more than 190 processing functions in formats for users at every programming level. $950.
Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077; 800/426-2200; in Oregon call collect, 503/627-9000
CIRCLE 326 ON READER SERVICE CARD

A source-form version of the **Modula-2 compiler** for porting to any computer system is available from **Modula Corporation**. Written by Niklaus Wirth, the author of Modula and Pascal, the new version is faster because it is based on the single-pass principle. The package includes the source code to the compiler and a portable debugger, a copy of the third edition of *Programming in Modula-2* (Springer-Verlag, 1985), and reports documenting the structure of the compiler and debugger. $1,000.
Modula Corporation, 1673 W. 820 North, Provo, UT 84601; 800/LILITH2; in Utah, 801/375-7400
CIRCLE 329 ON READER SERVICE CARD

Coefficient Systems Corporation has announced **VTERM III**, an enhanced version of the VTERM II integrated software package for communications between PCs and DEC VAX and PDP-11 computers. VTERM III combines VT100 terminal emulation, Kermit and multiprotocol file transfer, and asynchronous communications capability up to 19200 baud. It provides capabilities for the transfer of text and binary files with or without error correction and under local or host control. VTERM supports ASCII text file transfer, XMODEM, VTRANS7 and VTRANS8 protocols, and Kermit. $195; upgrade from VTERM II, $70; VTERM III with VT100 and Tektronix 4010 terminal emulation, $249.
Coefficient Systems Corporation, 611 Broadway, Suite 426B, New York, NY 10012; 212/777-6707
CIRCLE 330 ON READER SERVICE CARD

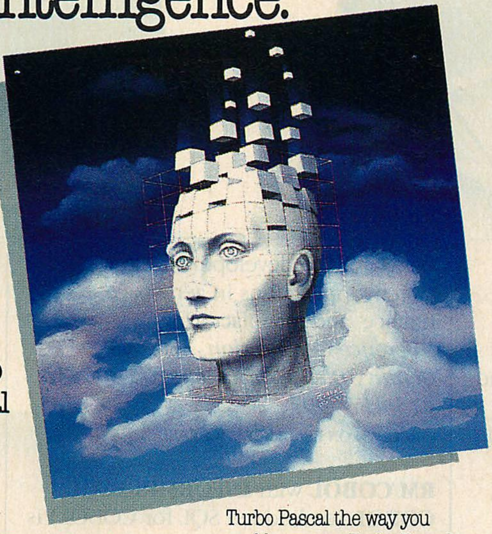
A C language compiler called **HOT C** has been introduced by **WordTech Systems, Inc.** The basic package contains the compiler, a C tutorial, a program editor, and a symbolic debugger. The compiler features a preprocessor, a code generator, an optimizer, a macro assembler, large and small memory models, and a UNIX-compatible function library. HOT C is not copy protected. $99.
WordTech Systems, Inc., P.O. Box 1747, 21 Altarinda Road, Orinda, CA 94563; 415/254-0900
CIRCLE 332 ON READER SERVICE CARD

A storage management utility package called **Arkive** has been announced by **Guaranteed Software**. Arkive is an automated file-tracking and archival program that is memory resident. It automatically and transparently creates and maintains a database; the user invokes a clean-up mode that scans the database and identifies obsolete files. These files are moved off the hard disk onto archive media, such as floppy disks, cartridge disks, or tape drives. $79.95.
Guaranteed Software, 10044 South DeAnza Blvd., Cupertino, CA 95014; 800/232-7222, in California, 800/331-6223
CIRCLE 333 ON READER SERVICE CARD

Security Microsystems Consultants has announced **LOCKIT II**, a package that lets the user of a hard-disk-based PC set up password protected subdirectories. Passwords may be changed at any time, and utilities are included to make files read-only and invisible. LOCKIT II can work in conjunction with LOCKIT I, an access control device that mounts on the motherboard and prevents boot up without a user-specified password. LOCKIT II is not copy protected. LOCKIT II, $79.95; LOCKIT I, $189.95.
Security Microsystems Consultants, 16 Flagg Place, Suite 102, Staten Island, NY 10304; 718/667-1019
CIRCLE 343 ON READER SERVICE CARD

Step-by-step tutorial, demo programs with source code included!

Borland introduces Turbo Prolog, the natural language of Artificial Intelligence.



Prolog is probably the most powerful computer programming language ever conceived, which is why we've made it our *second* language—and "turbocharged" it to create Turbo Prolog.™

Our new Turbo Prolog brings supercomputer power to your IBM® PC and introduces you step-by-step to the fascinating new world of **A**rtificial **I**ntelligence. And does all this for an astounding $99.95.

Turbo Prolog is to Prolog what Turbo Pascal® is to Pascal!

Our Turbo Pascal astonished everyone who thought of Pascal as "just another language." We changed all that—and now Turbo Pascal is the de facto worldwide standard, with hundreds of thousands of enthusiasts and users in universities, research centers, schools, and with professional programmers, students, and hobbyists.

You can expect at least the same impact from Turbo Prolog, because while Turbo Prolog is the most revolutionary and natural programming language, it is also a complete development environment—just like Turbo Pascal.

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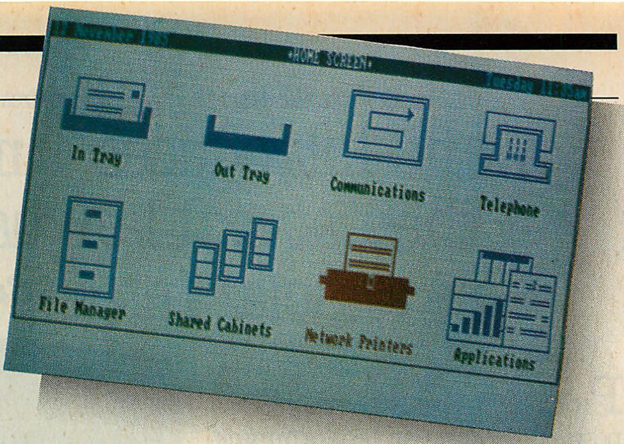
APL*PLUS from STSC



Tapestry communications screen by Torus

Torus Systems has announced **version 1.4** of **Tapestry**, a LAN software environment for NETBIOS-compatible network hardware. Version 1.4 offers enhanced external communications and improved compatibility with applications software. Tapestry 1.4 is required for Torus gateway products. Network manager pack, $495; workstation pack, $295; upgrade for registered users, $200; for unregistered users, $250.

Also from Torus comes **Remote Network Link** (RNL), which provides Tapestry users remote access to their network using ordinary telephone lines and a PC with a modem. No network adapter is required. $295.

Remote Access Gateway (RAG) **version 1.4** configures a Tapestry network to support RNL users. RAG allows any number of Tapestry workstations to act as undedicated remote gateway servers. It requires an auto-answer modem for each station that is to serve as a remote gateway. $250 per network.

Another product, **Advanced Gateway Support** (AGS), extends the asynchronous communications capabilities of a Tapestry network to provide VT100 emulation. For Tapestry networks running on 3Com hardware, AGS supports Bridge CS devices. $795 per network.

With **Torus 3270 SNA Gateway**, as many as 32 Tapestry users can have concurrent access to an IBM mainframe. The Gateway lets a Tapestry workstation emulate a 3274 cluster controller with a 3278 screen emulation. 8 ports, $5,495; 16 ports, $5,995; 32 ports, $7,495.
Torus Systems, 495 Seaport Court, Suite 105, Redwood City, CA 94063; 415/363-2418
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From **Inference Corporation** comes a RISC-based version of its expert system development tool. The **Automated Reasoning Tool** (ART) will be available for the PC/RT running IBM's AIX version of UNIX. ART is ported to the PC/RT for the development of expert system applications in aerospace, finance, and manufacturing.
Inference Corporation, 5300 W. Century Blvd., Los Angeles, CA 90045; 213/417-7997
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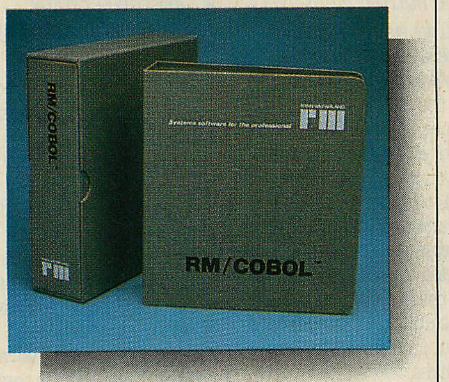
RM/COBOL with **INFORMIX-ESQL/COBOL** (embedded SQL for COBOL) is now available from **Ryan-McFarland Corporation**. This new capability allows RM/COBOL users to access Relational Database System's INFORMIX-SQL relational database via SQL (structured query language) statements embedded in their COBOL programs. These programs pass through an RDS translator to convert SQL statements to COBOL prior to compilation; the translated COBOL code then is able to interface with the relational database.



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Ryan-McFarland Corporation, 609 Deep Valley Drive, Rolling Hills Estates, CA 90274; 213/541-4828
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A runtime version for **release 5.0** of **APL*PLUS PC System** has been announced by **STSC, Inc.** This system for advanced applications development provides increased productivity by speeding up the development process with its concise and powerful APL language notation. The runtime version is specially modified to run a single application. This modified interpreter enables developers to include enough of the APL*PLUS PC System to run their applications but not enough to allow end users to write or modify their own APL programs. Prices based on royalties.
STSC, Inc., 2115 E. Jefferson Street, Rockville, MD 20852; 800/592-0050, in Maryland or Canada, 301/984-5123
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Microbench C is a C compiler from **Virtual Systems, Inc.** that produces highly-optimized code for the Intel 8086 family of microprocessors. Its runtime library provides a complete set of UNIX I/O services. The DOS version produces assembly language compatible with the Microsoft Macro Assembler. This compiler implements the Kernighan and Ritchie C language definition. $500.
Virtual Systems Inc., 1500 Newell Avenue, Suite 406, Walnut Creek, CA 94596; 415/935-4944
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SuperPATH from **Martin Scot Development Corporation** is a directory performance utilities package. SuperPATH lets the user run any program from any directory. It is resident in RAM for high-speed operation and allows the user to find files instantly. $39.95.
Martin Scot Development Corporation, 4515 Purdue NE, Seattle, WA 98105; 206/527-9605
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Erratum: In the hardware section of the May 1986 Tech Releases, the amount of DOS memory accessed by **RYBS Electronics' HiPage utility software** should read 704KB.

The material that appears in Tech Releases is based on vendor-supplied information. These products have not been reviewed by the PC Tech Journal *editorial staff.*

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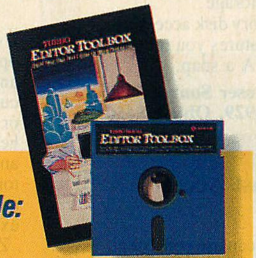

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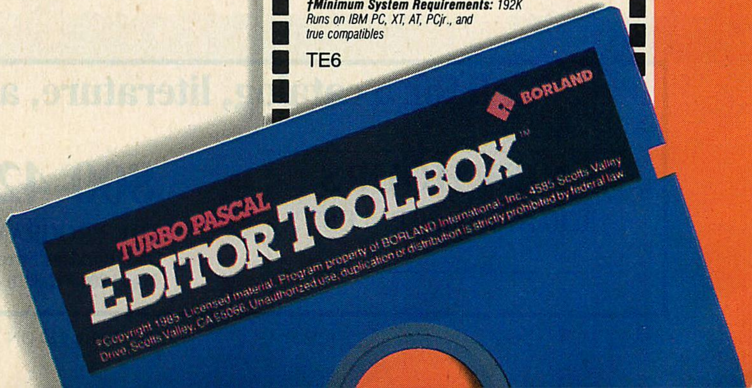

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RICHARD NORMAN

Video Function Call Fix

Using the code presented here, the BP register can be preserved when scrolling the screen even in high-level languages.

Calls to the ROM BIOS generally preserve all registers except those explicitly designated to return values, according to the IBM *Technical Reference Manual.* The video service call, INT 10H, is a notable exception: the BP register is altered any time the screen is scrolled. This can cause problems because the BP register is commonly used as a stack frame reference for subroutine linkage in high-level languages, and the video function call is an often-used service.

Programmers can avoid this problem when working in assembly language. However, programmers using compiled languages do not have control over the use of registers. Many ordinary programs are able to run successfully because the BP register is restored on return to the calling sequence. Problems are most likely to occur in a situation when direct BIOS calls are made from a high-level language—for example, when trying to scroll a window.

The source code described here (see listing 1), which is intended to fix this problem, patches the BIOS call itself. If installed as part of the system boot, this code, called VIDFIX.ASM, will correct any high-level programs that may run with occassional, unexplained crashes.

The source code shown in the listing must be assembled and linked before it can be installed. The resulting .EXE file can be converted to a .COM file using the DOS utility EXE2BIN. After the command VIDFIX is added to the AUTOEXEC.BAT file and the VIDFIX.COM file is included on the system disk, executing VIDFIX will install the program as a resident part of memory. This program substitutes for the original INT 10H call and adds the appropriate PUSH and POP. The installation code provides a test to ensure that the code is installed only once.

Apparently the problem of INT 10H was discovered after the BIOS was embedded in ROM—this is the only BIOS call for which the prologue to the source code mentions that some registers (DI, SI, and BP) are destroyed. However, the code itself clearly shows that the SI and DI registers are restored. Only the BP register is not preserved, and it was obviously an oversight not to include this register in the long list of PUSHes and POPs.

Richard Norman is a member of the faculty at the University of Michigan at Dearborn. He has a Ph.D. in communications sciences.

LISTING 1: VIDFIX.ASM

```
; VIDFIX.ASM            R. Norman              Nov. 11, 1985
; Fix BIOS Video Interrupt 10H to save BP register
; Install a resident program patch into the operating system.
;
; Script to assemble into COM file:
;       MASM VIDFIX;
;       LINK VIDFIX;
;       EXE2BIN VIDFIX.EXE VIDFIX.COM
;
; Make sure VIDFIX.COM is on boot disk and include the line
;    VIDFIX
; in AUTOEXEC.BAT
;

CSEG    SEGMENT
        ASSUME CS:CSEG

VIDFIX  PROC    FAR
        ORG     0100H
ORIG:   JMP     INSTALL         ;installation skips over resident code

                                ;resident data area
OLD10   DD      ?               ;save area for original INT 10H vector
ID      DW      'RN'            ;id code to test for re-installation

EXEC:                           ;beginning of executable resident code
        PUSH    BP
        PUSHF                   ;simulate INT call
        CALL    CS:OLD10        ;old INT 10 executes STI and RETI
        POP     BP
        RET     2               ;clear old flags from stack
ENDEXEC:                        ;end of executable resident code

HELLO$  DB      0DH,0AH,'Install INT 10H fix ',0DH,0AH
        DB      'R. Norman,  Nov. 11, 1985',0DH,0AH,'$'
ALREADY$ DB     0DH,0AH,'INT 10H fix already installed. Request
                ignored.'
        DB      0DH,0AH,'$'

INSTALL:                        ;beginning of installation code
        ASSUME DS:CSEG
        MOV     DX,OFFSET HELLO$
        MOV     AH,9
        INT     21H             ;logon
        MOV     AL,10H
        MOV     AH,35H
        INT     21H             ;get current INT 10H vector into ES:BX
        CMP     ES:[BX-2],'RN'  ;if test id is present
        JE      NOINST          ;  it is already present
        MOV     WORD PTR OLD10,BX
        MOV     WORD PTR OLD10+2,ES     ;save current vector
        MOV     DX,OFFSET EXEC  ;note, DS already has segment of EXEC
        MOV     AL,10H
        MOV     AH,25H
        INT     21H             ;reset interrupt 10H to new code
        MOV     DX,OFFSET ENDEXEC       ;length of resident code
        INT     27H             ;terminate and remain resident

NOINST:                         ;here, exit without installation
        MOV     DX,OFFSET ALREADY$
        MOV     AH,9
        INT     21H             ;say it is already installed
        INT     20H             ; and terminate normally
VIDFIX  ENDP
CSEG    ENDS
END     ORIG
```

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Richard M. Foard, PC Tech Journal, October 1985.

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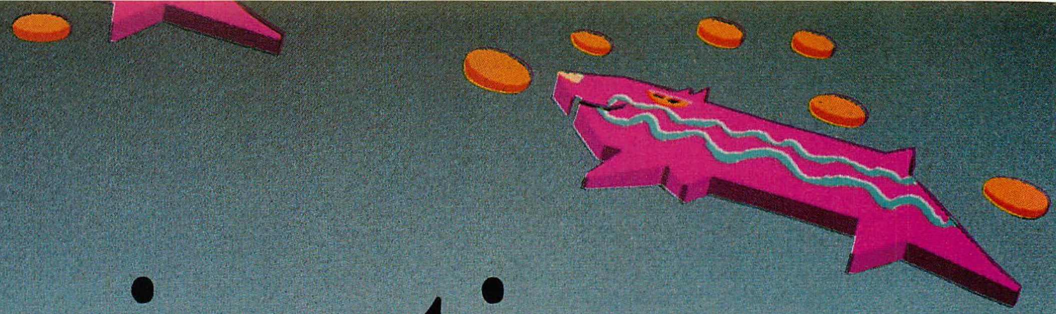

Animation Techniques

Better with less in a different way: animation device drivers that bring speed and performance to the CGA.

MICHAEL ABRASH and DAN ILLOWSKY

Why did not any of the children in the first group think of this faster method of going across the room? It is simple. They looked at what they were given to use for materials and, they are like all of us, they wanted to use everything. But they did not need everything. They could do better with less, in a different way. —Frederik Pohl
The Gold at the Starbow's End

Like all humans, programmers sometimes substitute preconceptions, assumptions, and entrenched thought patterns for original thought. Because compilers and interpreters generally provide them with virtual environments largely unrelated to the underlying hardware, programmers implicitly make myriad assumptions about the rudimentary implementation of their programs. This, of course, is generally all to the good, as the human mind is incapable of effectively integrating all the details involved in a large program, as well as the minutia of the computer's architecture. By delegating all of the hardware considerations and many of the software details to the compiler/interpreter designers, programmers are free to concentrate on overall program structure. This is, after all, their primary concern.

Not so with realtime drivers for microcomputers, and especially not so with drivers such as those for animation that depend for their very effect upon realtime human perception. Here speed becomes paramount, and any abstraction or delegation can lead to diminished effect due to reduced performance. Indeed, in this area even assembly language is not enough: an understanding of the hardware beneath the assembly language level is required, and

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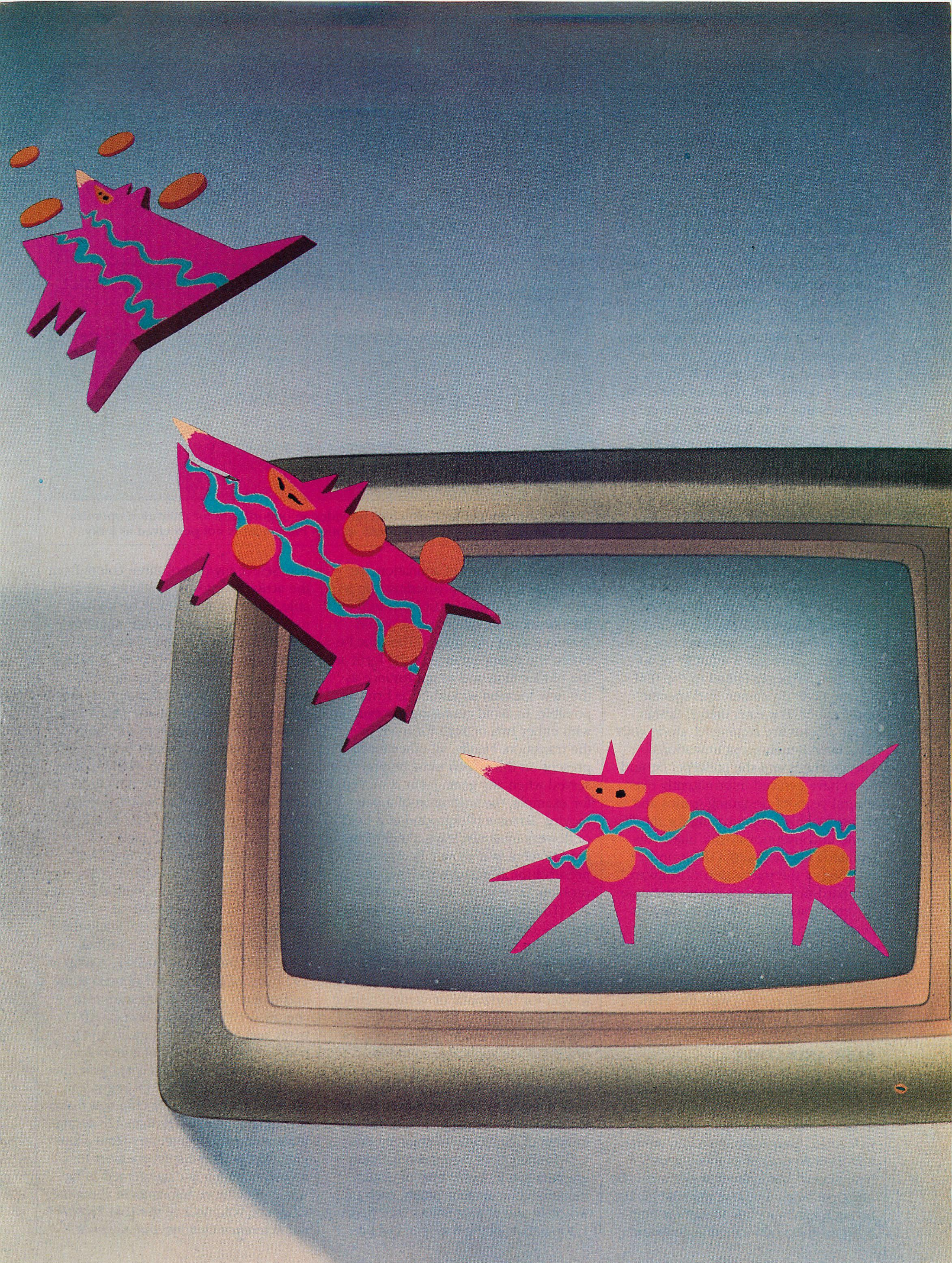


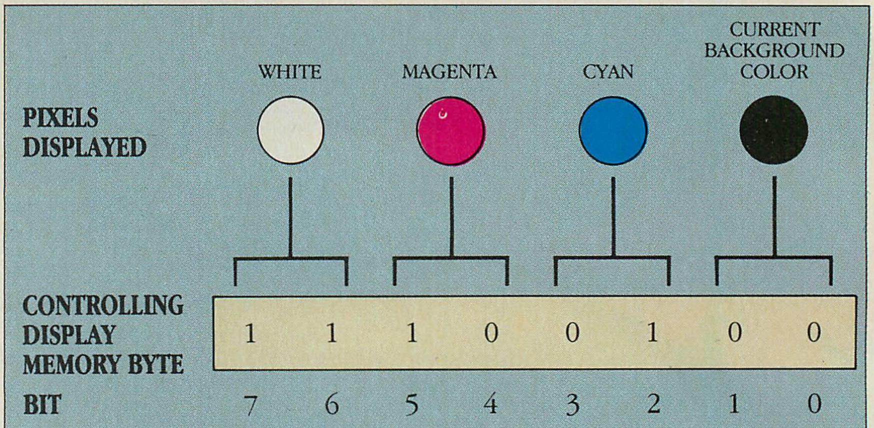
something more as well. That something more is an ability to, as with the children in the quote above, "do better with less, in a different way." Even dearly held assumptions about programming techniques must be questioned, because those assumptions, while generally valid, may serve poorly for a given processor performing a given task. For realtime drivers (particularly those written for a relatively slow processor such as the 8088), the object is to generate, by any means, code that will perform precisely the task required in the fewest machine cycles.

If this is hacking, then it is hacking in the finest sense. The PC's hardware is being asked to do a task it is barely capable of doing: this requires stretching the rules that normally make life easier. Structured coding, top-down design, and all the rest are excellent practices—but only when they facilitate the task at hand. Standard programming practices do not provide optimal solutions for applications such as animation drivers, where performance must take precedence over considerations such as portability and even readability.

This article presents a series of animation drivers for the IBM Color Graphics Adapter (CGA), beginning with a conventional implementation and proceeding through a number of approaches far better suited to the IBM PC, the 8088 processor, and specific applications. For each driver, design requirements are examined, along with associated benefits and limitations. These drivers and the concepts behind them have evolved intermittently over several years of designing games and doing systems programming for the PC. Some unconventional (but highly disciplined) thinking and a deep understanding of the interaction of software and hardware went into these realtime drivers, designed to wring maximum performance from a microcomputer.

All assembly language code included here was assembled with the Microsoft Macro Assembler 4.0, and all C code was compiled with the Mark Williams C compiler 2.0.

FIGURE 1: *Byte/Pixel Mapping for the CGA*



HIGH BIT	LOW BIT	PIXEL COLOR
0	0	Background (1 of 16, normally black)
0	1	Green (palette 0)/cyan (palette 1)
1	0	Red (palette 0)/magenta (palette 1)
1	1	Brown (palette 0)/white (palette 1)

The four-pixels-per-byte structure provides an opportunity for animation optimization because a four-pixel horizontal motion increment is not perceived as jerky.

BASIC ANIMATION

Animation is the process of repeatedly redrawing a form in successive locations rapidly enough so that it appears to move like a real object. All arcade-style video games are based on animation; however, most of those games have special hardware that performs the principal work. Because the IBM PC has no such hardware, all animation functions must be performed in software.

The basic rules of animation are few. Each time a form is redrawn in a new location, it also must be erased at the old location; otherwise, it would leave a trail of old images. The time between the disappearance of the form at the old location and its appearance at the new location should be as brief as possible, to avoid confusing the eye with either two or zero forms during the transition. Finally, all other forms present on the screen must be preserved when any given form is moved; for example, the animation of a bee moving across a background of a field of flowers must not leave a trail of erased flowers as it moves. Background preservation is perhaps the biggest problem in animation driver design.

The descriptions here assume the drivers' operation in four-color, medium-resolution graphics mode on the CGA. This permits access to display memory at any time, rather than having to wait for horizontal or vertical retrace to avoid snow, as is the case in high-resolution mode. The techniques discussed are applicable to monochrome graphics boards and to the IBM Enhanced Graphics Adapter (EGA) as well, although significant modifications would have to be made to take full advantage of the EGA's 16-color modes.

In the CGA's medium-resolution graphics mode, every byte of display memory controls four pixels, each of which is one of four colors (see figure 1, top). Each of the four pairs of bits may select any one of three colors from the active palette (two palettes are available, either of which may be high or low intensity) or the background color (which may be any one of the PC's 16 colors)—see figure 1, bottom. If palette 1 (consisting of cyan, magenta, and white) with a black background is the current color selection, then each byte maps to the four pixels in the figure.

Each scan line has 80 bytes, or 320 pixels, across the screen. The top scan line (scan line 0) is defined by the bytes at addresses B800:0000 through B800:004F, the second (scan line 1) at addresses B800:2000 through B800:204F, the third (scan line 2) at B800:0050 through B800:009F. This mode has 200 scan lines, with the even scan lines in the lower 8KB at B800:0000 through B800:1FFF and the odd scan lines in the upper 8KB at B800:2000 through B800:3FFF. A total of 192 bytes of RAM are left unused at the end of each group of 100 scan lines (because 100 scan lines occupy 8,000 bytes and each group is given 8,192 bytes). This separation of a graphics buffer into halves by alternate scan lines is a consequence of a 7-bit register in the 6845 CRT controller chip that makes it unable to map more than 128 contiguous scan lines in memory from a single address. The display memory-to-screen mapping is diagrammed in figure 2. (For more information about the CGA, see volume 2 of the IBM *Technical Reference Options and Adapters*

manual and "The IBM Color Graphics Adapter," Thomas V. Hoffmann, *PC Tech Journal*, July/August 1983, p. 26.)

Textbooks on graphics generally build graphics drivers around a function that plots a single pixel. This approach draws a form by plotting each of the points that make up the form with a separate call to the pixel-plotting routine. The form-drawing routine must calculate the coordinates of each pixel in turn; the call to plot each point then incurs the full overhead required to calculate the display memory address at which to plot the pixel, as well as the overhead of calling and returning from the pixel-plotting routine.

This general (and very slow) approach is well suited to powerful mainframes but it is out of the question on the PC, where even the fastest driver can animate only a few dozen sizable forms simultaneously. The drivers presented here work with solid rectangular areas of the screen, modifying not single pixels but whole bytes with each display memory access. The form to be displayed is contained within the area. This approach offers the advantage of moving a predefined string of bytes constituting a rectangular form into screen memory in a single very rapid operation, with minimal calculation and processing overhead. Because these are byte-oriented rather than pixel-oriented drivers, forms must move a multiple of four pixels horizontally. In practice, this is not too serious a limitation, but a two-pixel movement increment is better. Internal animation (discussed below) can overcome this limitation.

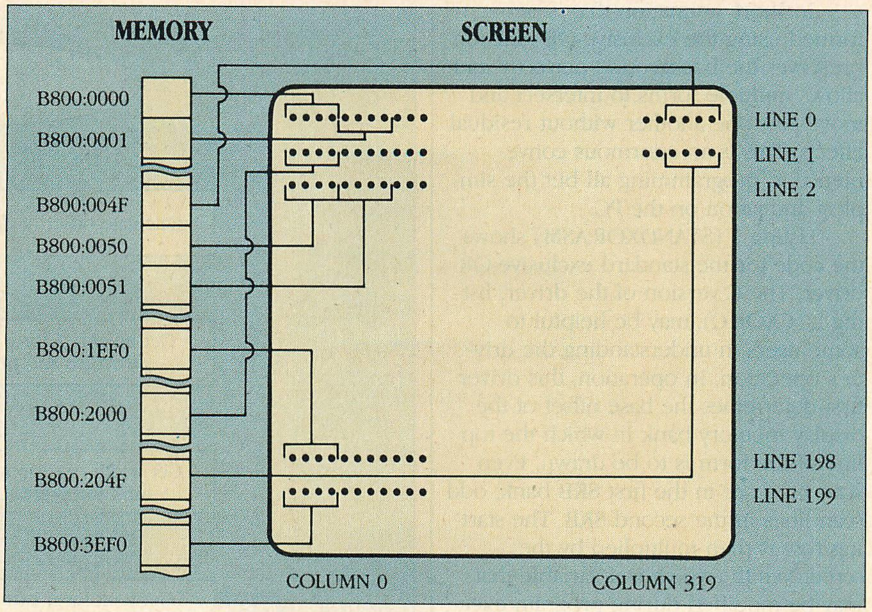
EXCLUSIVE ORing

All of these drivers are called with the same interface: the row and column coordinates of the upper left corner of the form to be drawn and a pointer to a data structure describing the form are passed in registers BX, CX, and SI, respectively. The row coordinate is the scan line at which the top of the form is to be aligned, in the range 0 to 199, with limitations as noted for specific drivers. The column coordinate is the byte offset from the left margin of the screen at which the left edge of the form is to be aligned, in the range 0 to 79. The data structure contains the height in scan lines, the width in bytes, and the string of bytes that make up the form, as shown in figure 3.

For all of the animation drivers listed with this article, the following conventions hold:

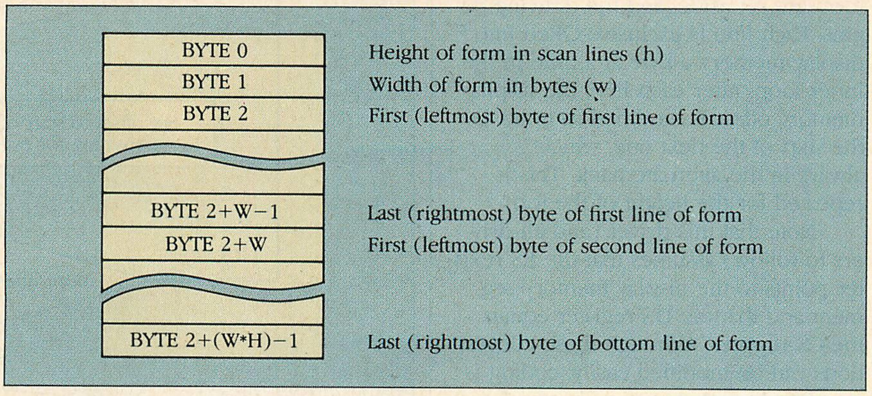
- DS and CS must be the same.
- ES must contain B800H.

FIGURE 2: *CGA Buffer Structure*



Odd-numbered lines have an additional offset of 2000H into the buffer, dividing the buffer into 8,192-byte halves. The last 192 bytes of each half are not used.

FIGURE 3: *Form Data Structure*



The width (W) figure here is in bytes, not pixels. (Each byte describes a total of four pixels.) The total memory required for a given form is given by (W * H) + 2.

- BX contains the row value (0 to 199) for the top of the image.
- CX contains the byte column (0 to 79) for the left edge of the image.
- SI points to the data structure that contains the image description. The first byte is the height (h) in scan lines; the second byte is the width (w) in bytes. The bytes that follow (numbering $h * w$) contain the values to be placed in the screen memory map: the organization of h consecutive sets of w line image bytes.

Conceptually, the exclusive-OR driver is the simplest of animation drivers. It introduces the fewest complications into animation programming and is, consequently, the most widely used animation technique.

The exclusive-OR logical function yields 1 for operands that differ and 0 for operands that are identical: 1 XOR 0 = 1, 1 XOR 1 = 0, and so on. XOR has the handy property of being perfectly reversible—that is, when a program performs two identical exclusive-OR operations in succession, the second undoes the effects of the first. Practically speaking, when the program performs an exclusive OR on a form into display memory once, it draws the form, and when it does an exclusive OR on the same form at the same location a second time, it removes all traces of the form. This is true even if (between the two operations) other forms have been drawn overlapping or overwriting the first form, as long as all drawing is

done by exclusive-OR. (Figure 4 shows a flowchart of this driver.)

In short, animation that is performed using the exclusive-OR function preserves the background perfectly and allows multiple forms to intersect and move past one another without residual effects. This is an enormous convenience in programming all but the simplest animation on the PC.

Listing 1 (STANDXOR.ASM) shows the code for the standard exclusive-OR driver. The C version of the driver, listing 2 (CXOR.C), may be helpful to some users in understanding the driver's operation. In operation, this driver first determines the base offset of the display memory bank in which the top line of the form is to be drawn. Even scan lines are in the first 8KB bank, odd scan lines in the second 8KB. The starting row is then multiplied by the screen width (which is a variable that may be modified during program execution) and added to the bank base address and the starting column to generate the offset at which the upper left corner of the form is to go.

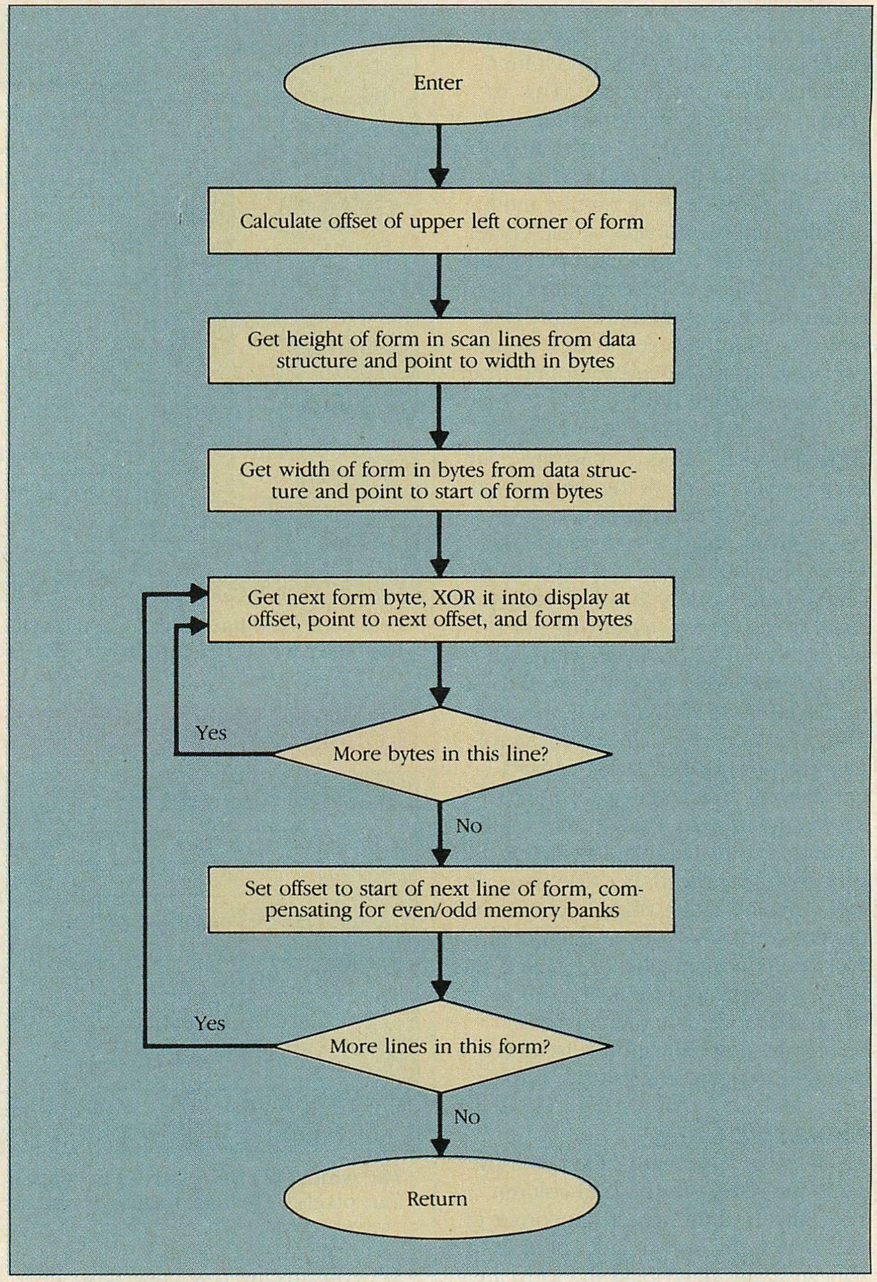
Next, the height and width of the form are set aside, and the drawing begins. Each line is exclusive-ORed into display memory a byte at a time in the inner loop. After each line, the display memory offset is modified to point to the start of the next line, which is always in the alternate bank. This is repeated for the height of the form.

Note that this driver (and all drivers to follow) assumes that the ES register points to the display memory segment and that the DS register equals the CS register. Although these conventions can be modified easily, coding is simplified when they are observed.

Listing 3 (XORBENCH.ASM) is a sample implementation the exclusive-OR driver, and it is used as a benchmark for the drivers. This program (which should be linked to listing 1) bounces eight forms around the screen, minimizing considerations other than driver speed. For the sake of clarity, no attempts were made to optimize this benchmark program. This reflects the real world, in which optimization primarily is performed in drivers, while the calling routines are more concerned with program structure. Thus, the relative differences between the performance of the drivers themselves are somewhat greater than the results, as shown in table 1, would indicate.

The programs were run on an IBM PC with the files executed from AST's RAM-disk software on an AST MegaPlus multifunction board; a stopwatch was

FIGURE 4: *XOR Driver Logic*



The exclusive-OR driver that follows this algorithm is the standard against which all the improved drivers developed in this article are measured.

using for the timings. These benchmark times would vary somewhat with a different mix of forms: the more efficient drivers gain a relative advantage with larger forms. Also, because the various drivers have markedly different characteristics, listing 3 is modified slightly (as noted in the source code) to accommodate the non-exclusive-OR drivers, although all versions of the benchmark perform the same function of moving eight objects in the same patterns.

Two characteristics of exclusive-OR drivers should be noted when running listing 3. First, odd color effects can occur when forms overlap. This is an unavoidable result of two forms being exclusive-ORed into the same area of display memory at the same time. The animation screen shown in photo 1 illustrates this problem. Second, the forms flicker; but, this can be minimized in two ways. If all forms are drawn during retrace time, then no flicker will be present; unfortunately, animation will slow to a crawl because retrace time is a small fraction of total time. Alternatively, the time between erasing a figure at the old location and drawing it at the new location can be kept to an mini-

mum. For simplicity, the benchmark program does not *absolutely* minimize this transition time, but it does keep it very low. Even so, flicker is unavoidable with this type of driver.

WHY .ASM?

CXOR (listing 2) is the C implementation of the benchmark program (listing 3) and exclusive-OR driver (listing 1). DRIVECXOR.ASM (listing 4) is an assembly language subroutine that performs an exclusive-OR to bring each byte into display memory; it must be linked to the C program of listing 2. The assembly language routine, which permits access to display memory without using the C compiler's slow, large memory model, is nothing more than an exclusive-OR poke function. All of the intelligence involved in moving the form itself is written in C.

The C exclusive-OR driver called from the C version of the benchmark is 3.79 times slower than its assembly language counterpart (as shown in table 1)—too slow to be of much use, even though register variables are used and the loops are small and simple. The reasons for its slowness are many: first, only two register variables are available, so some variables must be kept in memory, making instructions longer and lengthening execution times; second, an assembly language subroutine must be called and parameters passed on the stack because this C implementation cannot access display memory directly in the small memory model; and, finally, C compilers do not use registers optimally for this particular application. For example, this driver reserves the BP register for stack addressing, but in this instance it would be better used for temporary storage of an offset. Similarly, the LOOP instruction is not available because the CX register is reserved for other purposes.

Other C compilers could ease some of these problems. Microsoft C, for example, can access display memory directly in the small memory model. But aside from the slowness problem, a more serious objection to coding animation drivers in C is that none of the techniques used by the more advanced drivers to be discussed can be used in C. Although often touted as a high-level assembly language, this is true of C only if the user is willing to accept the implementation assumptions a C compiler must make about an application in order to produce machine code. In this case, all registers and instructions of the 8088, as well as unusual program flow control structures, must be at the user's complete disposal. The C language can provide none of these.

TABLE 1: *Benchmark Timings*

ANIMATION DRIVER	BENCHMARK TIME	RATIO TO STANDARD DRIVER
Standard exclusive-OR driver (listings 1, 3)	42 seconds	1.00
C version of standard exclusive-OR driver (listings 2, 4)	159 seconds	3.79
Optimized exclusive-OR driver (listings 3, 5)	32 seconds	0.76
Exclusive-OR driver with in-line column code (listings 3, 6)	26 seconds	0.62
Exclusive-OR driver with full in-line code (listings 2, 7)	25 seconds	0.60
Byte-move graphics driver (listings 8, 9)	10 seconds	0.23
Byte-move driver with automatic erasure fringe (listings 8, 10)	8 seconds	0.19

The programs were run from a RAM disk on an IBM PC; a stopwatch was used for all timings. The figures for the driver implemented in C suggest that no substitute exists for assembly language when performance considerations are paramount.

C advocates may note that the driver could be coded in assembly language and called from C. This is the point exactly: optimal realtime drivers must be written in assembly language. Accept no substitutes.

Of course, this does not mean that just any assembly language code will do. The code must, for example, make optimum use of registers and instructions. After all, if a driver written in assembly language kept all its variables on the stack, and reserved each register for a specific purpose at all times, the code might as well be written in C.

The exclusive-OR driver in listing 5 (OPTXOR.ASM) cuts benchmark time (when linked with listing 3) from 42 to 32 seconds by performing such optimizations. First, it keeps all variables in registers at all times. Second, it uses more efficient instructions, especially the LODSB string instruction. (Note that it is assumed a CLD has been executed in the calling program to cause string instructions to autoincrement the pointers they use.) Third, it does not preserve any of the general registers. Fourth, it uses a table look-up to calculate the display memory offset of the start of the row. Fifth, it does the calculation of the offset to the start of the next line of the form in display memory outside the main loop. It is always best to do work once instead of repetitively. This change also means that the program no longer has to push and pop the starting offset of each line.

The slow memory access of the PC's 8088 mandates keeping all variables in registers. Register-only operations tend to execute in 4 cycles or less, while memory-to-register and register-to-memory operations take a minimum of 10 cycles, and more commonly require 14 or more. (These times assume that the instruction has been prefetched; the state of the instruction prefetch queue can change them considerably, but register-only operations are still faster.) To derive maximum benefit, all general-purpose registers are used, including the BP register.

This slow memory access is also the reason registers are not preserved. Pushing and popping the seven general-purpose registers would take 182 cycles. Instead, the calling routine decides which registers need to be preserved. Two concerns result from this move. First, it increase code size, but memory is cheap, second, programmers must be alert, as bugs could result from undisciplined programming. However, because speed is paramount to this application, the code cannot be expected to compensate for the programmer.

The use of a table look-up to calculate the display memory offset of the row (by multiplying the row by the screen width in bytes) is illustrative of several key points. First, it is an example of, as author Pohl put it, doing better with less. The MUL instruction is available (and tempting) to the programmer; however, by ignoring it and restricting the driver to display memory of a fixed width (and by using a little more memory) as many as 50 to 100 cycles can be saved. If support for multiple display memory widths were needed, it would be better simply to

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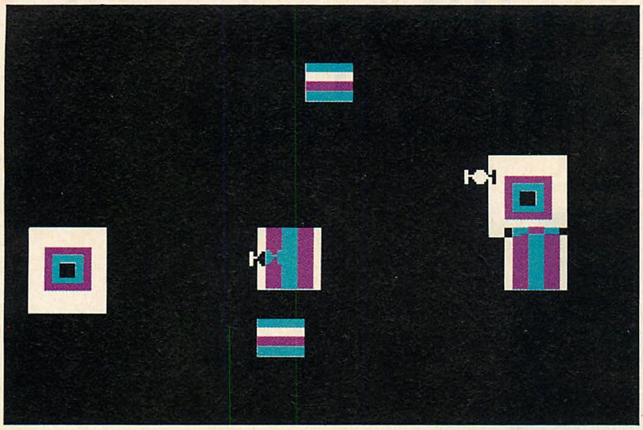
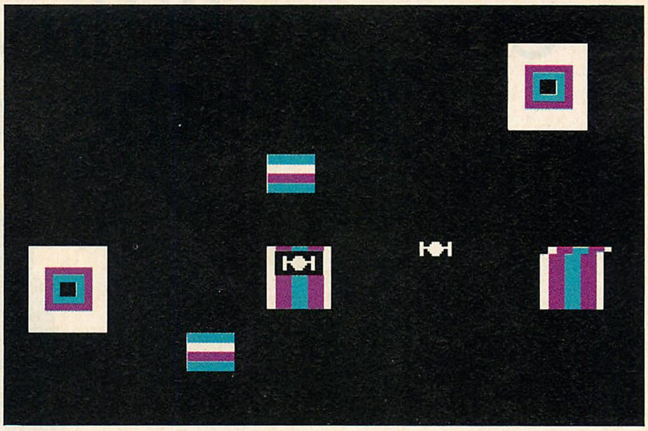
PHOTO 1: *XOR Animation Driver*



These unavoidable false-color effects are less annoying than accompanying form flicker (not shown here).

PHOTO 2: *Byte-fringe Driver*



The trailing edge of the partially moved box above is being erased by the figure's blanking fringe.

write multiple dedicated drivers. Memory is cheap, and, perhaps more importantly, general-purpose drivers are slow.

In addition, a key assumption was made in writing this driver. It was assumed that all forms start on even scan lines and are an even number of scan lines high; that is, the row coordinate that the driver is passed will always be even, and the height of the forms will always be even. Generally, at animation speeds, the human eye cannot detect single-pixel and double-pixel movement increments apart (remember also that the horizontal increment is four pixels), and the even-scan-line assumption means that the table look-up can be speeded up a little. Normally, the program might take the row coordinate, multiply it by two by shifting it left, and then use it as the index to look up the product of the multiplication by the screen width. By assuming an even scan line, however, the need for the shift is removed. This in itself is minor, although it does cut the size of the look-up table in half. This assumption also permits the assumption that form drawing always starts in the lower 8KB of display memory (that is, relative to a base of 0000H rather than 2000H), saving some testing performed in the original driver. Similarly, the assumption of an even number of scan lines per form permits two exclusive ORs in a row, saving a LOOP instruction. These assumptions also simplify other drivers.

The point is not that these assumptions must be made in designing *any* animation driver, rather that they worked for this application. Effective driver design consists largely of paring away cycles by knowing what must be kept and what can go in a particular circumstance. For example, a few more cycles could be saved by storing the height of each form divided by two in the form data structure, so AL would not have to be shifted right to divide by two. But this would have resulted in only a small savings at the cost of changing all the form data structures and introducing confusion. Saving even one cycle inside the driver loops is always worthwhile because of the multiplier effect of the loops, but a few extra cycles outside the loops are not nearly as significant, and may be removed or left in at the programmer's discretion. The balance is application-dependent: when most of the forms are large, loop efficiency is paramount, but with smaller forms, the overhead outside the loops takes on added importance.

Third, a table look-up is used rather than multiplying by 80 with shifts and adds (see figure 5), even though the nominal time for the latter approach is faster. This method was chosen because the 8088 microprocessor must fetch instructions before it can execute them, and it cannot fetch them any faster than memory access speed will allow. For the PC, this means four cycles are required to fetch every instruction byte. Shifts and adds are supposed to take two and three cycles, respectively, and indeed they do, but because both are two-byte instructions, eight cycles are required to fetch them. The instruction prefetch queue for the 8088 is only four bytes long, so even under the best conditions two such instructions in sequence will deplete the queue, after which they effectively take eight cycles each. The result is that the multiply-by-80 code shown in figure 5 actually takes longer than the table look-up, even though, according to specifications, the code in this figure should execute in 17 cycles and the table look-up should execute in 21.

(Note that considerations such as instruction queue interaction are inferences rather than specifications, learned through experience and experimentation. Short of a full knowledge of the internal state of the 8088, no method exists to determine exactly how long a particular code fragment in a given program will take to execute.)

ALTERNATIVE EXCLUSIVE-OR

The last exclusive-OR implementation began to blur the line between a straight assembly language implementation of an algorithm and an unconventional approach. That line is crossed with INLINXOR.ASM, the driver in listing 6. Here is another exclusive-OR driver, functionally identical to the driver just discussed except that the inner loop of the code that moves the form into the screen has been replaced with a call to in-line code.

The 8088 is relatively slow at memory access and branching: JMP requires 15 cycles, a conditional jump requires 16 cycles, and LOOP requires 17 cycles if a jump is made. In fact, this CPU is considerably slower at branching than a Z80 running at 4 MHz. (The 8088 is, of course, a more powerful processor by virtue of its additional registers and memory addressing modes and a much larger address space.) The use of registers wherever possible compensates for the slow memory access; in-line code will compensate for slow branching.

By calling in-line code, the program branches only twice each time a scan line of the form is drawn (once to call the routine and once to return from it) rather than once per byte (with the LOOP instruction). Because the

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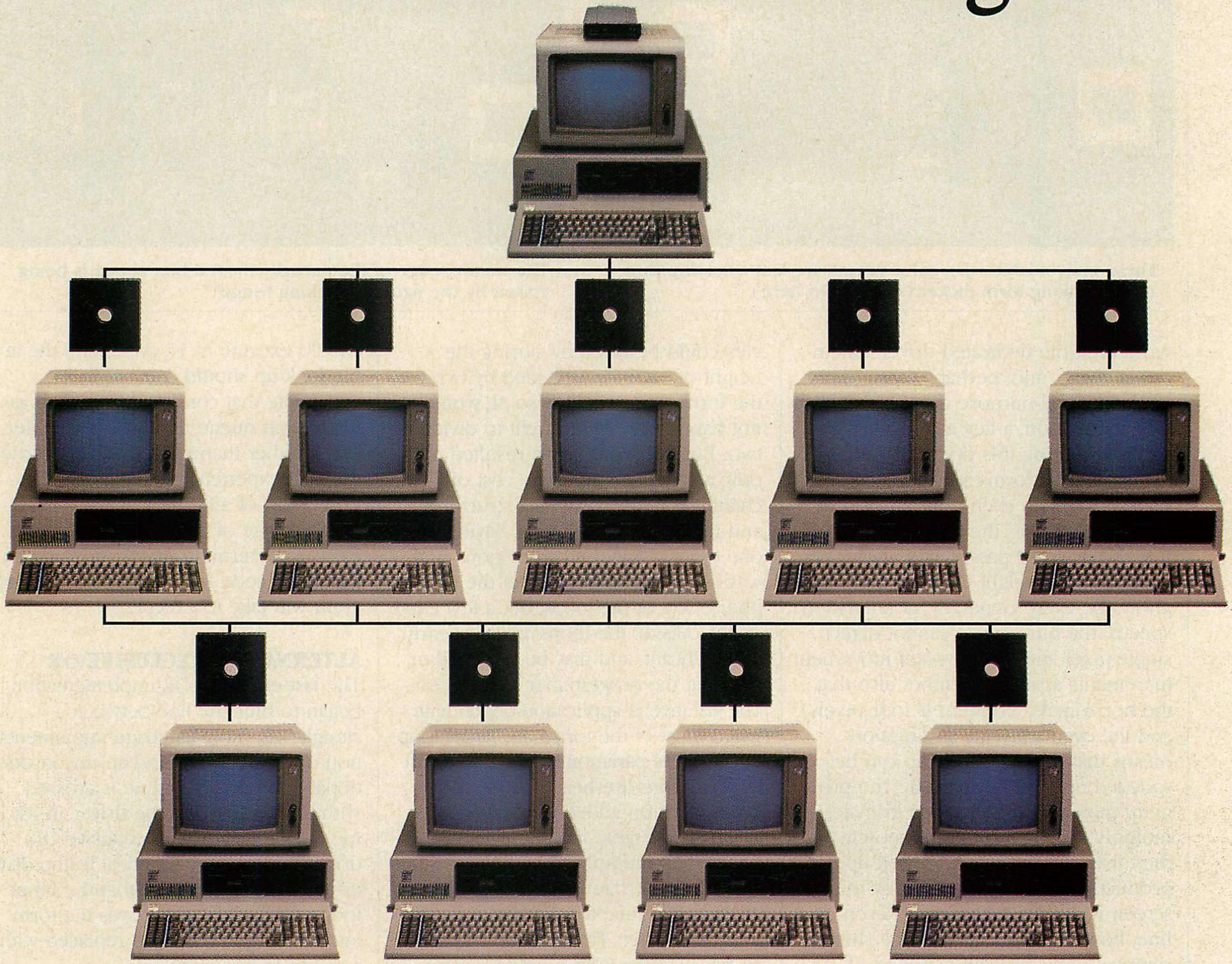

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FIGURE 5: *Shift/Add Multiplication by 80*

```
;
; Code fragment to multiply row value in BX by 80 and put it in DI.
;
        shl     bx,1     ;row*2
        shl     bx,1     ;row*4
        shl     bx,1     ;row*8
        shl     bx,1     ;row*16
        mov     di,bx    ;set aside row*16
        shl     bx,1     ;row*32
        shl     bx,1     ;row*64
        add     di,bx    ;row*80 = row*64 + row*16
```

These machine instructions take fewer cycles than table look-up, but the additional overhead of fetching them from memory makes their operation slower.

branch address is calculated outside the main loop, it adds little overhead—only 26 cycles. The in-line code saves 53 cycles per scan line for a 5-byte (20-pixel) wide form. The savings are relative to the size of the form; they are greatest for larger forms, which affect overall performance the most. The benchmark timings confirm that this approach improves driver performance significantly.

This is yet another example of doing more with less: The LOOP instruction is available for just such cases as the loops in an animation driver, and, by reflex, the programmer would use it, just as the chip's designers intended. It requires an act of will to examine the loop element of the driver and reject it as too slow, in favor of another, albeit less conceptually elegant, approach.

Ideally, all code that comprises the entire main loop, not just the inner loop, would be in-line code. This step is accomplished in RCINXOR.ASM (listing 7) where the animation driver calculates an offset into in-line code based on the number of rows, and the row in-line code calls the column in-line code. This process eliminates all LOOPs associated with the main (row) loop in favor of a single calculated jump. A jump instead of a call to the row in-line code is used, thus control can return to the calling program when the row in-line code is finished (because the animation driver is then finished).

The benchmark results indicate that adding in-line code for the row loop does not greatly improve the performance of the exclusive-OR driver. This is not surprising considering that the row loop is the outer loop and is executed much less often than the inner loop. However, the concept of fully in-line code proves to be far more beneficial with the next driver.

(In-line code drivers must have enough in-line code to handle the maximum expected number of rows and columns for the largest form in the animation—a jump outside the in-line code would be disastrous.)

The calculated call to in-line code is the sort of technique that is essential to high-performance 8088 code. An obscure approach, one that is frowned upon because it involves multiple entry points to code and creates the potential for serious bugs, but it brings results—in the case of listing 7, a 68-percent faster execution of the benchmark application. The more esoteric approaches that follow further illustrate the necessity of innovative programming approaches in compensating for CPU deficiencies.

THE BYTE-MOVE DRIVER

The exclusive-OR approach offers many advantages with only a few drawbacks: an inevitable flicker when a form is moved, odd color effects when forms intersect (as the colors of the two forms are exclusive-ORed together), and a slow performance. Almost any arcade-style game for the PC will demonstrate these effects, and most of these games have only a few small, flickering forms moving at any one time. Support for dozens of figures moving simultaneously requires a different type of driver. Another close look at the architecture of the PC provides direction.

A higher-performance driver should minimize memory accesses (particularly display memory accesses because the CGA inserts wait states on 8088 accesses to display memory), reduce the instruction queue bottleneck, and keep branching to an absolute minimum. Ideally, it should perform memory accesses faster and perhaps provide a way of reducing the number of times the driver needs to be called per form movement from twice to once.

An inspection of the 8088's instruction set reveals one group—the string instructions—that offers remarkable (and very helpful) properties. For example, the MOVS instruction can move a byte from a source to a destination and increment both pointers in 18 cycles—less time than the XOR instruction alone requires in the exclusive-OR driver. The REP prefix allows MOVS to operate repeatedly without branching. Using REP MOVS, the entire inner loop of the driver (the loop that draws a single form line) can be reduced to $9 + 17 * n$ cycles, where n is the number of form bytes on the scan line.

No string equivalent of the XOR instruction exists, so MOVS, which is the string equivalent of the MOV instruction, has to serve. The remainder of the drivers use MOVS, and, as a result, have fundamentally different properties from exclusive-OR drivers.

Listing 8 (BYTEMOV.ASM) is the byte-move equivalent of the exclusive-OR driver. It actually has two drivers, one to draw the form and one to erase it (the byte-move approach is not reversible like the exclusive-OR approach). When a form is to be moved, the main program first calls the erase routine to remove the form from the screen and then calls the draw routine to redraw it in the new location.

The erase routine uses the STOS instruction, which is faster than MOVS because it uses AL rather than memory for the source operand to clear the form from the screen. Both drivers use the in-line code, table look-up, and register optimization techniques discussed previously; however, in-line code works much more effectively with these drivers. This is the case because while the exclusive-OR drivers require two levels of in-line code, one to handle the rows and one to handle the columns in each row, the byte-move driver requires only one level, for the rows. The columns in each row are handled neatly by the REP operation of MOVS and STOS, providing the ideal solution for the innermost (column) loop—no branching and no in-line code. This also permits dispensing with the innermost loop and the return from it that was required by the exclusive-OR driver.

Another good point: the byte-move driver averts an instruction bottleneck because the 8088 holds the MOVS instruction internally through the entire REP operation. Thus, not only does the 8088 not have to keep fetching instructions during the REP operation, it also can fill up the prefetch queue. Because the number of instruction bytes between one REP MOVSB and the next in the in-line code is six and the size of the instruction prefetch queue is four, for forms that are more than one or two bytes wide the 8088 should be able to prefetch all the bytes up until the

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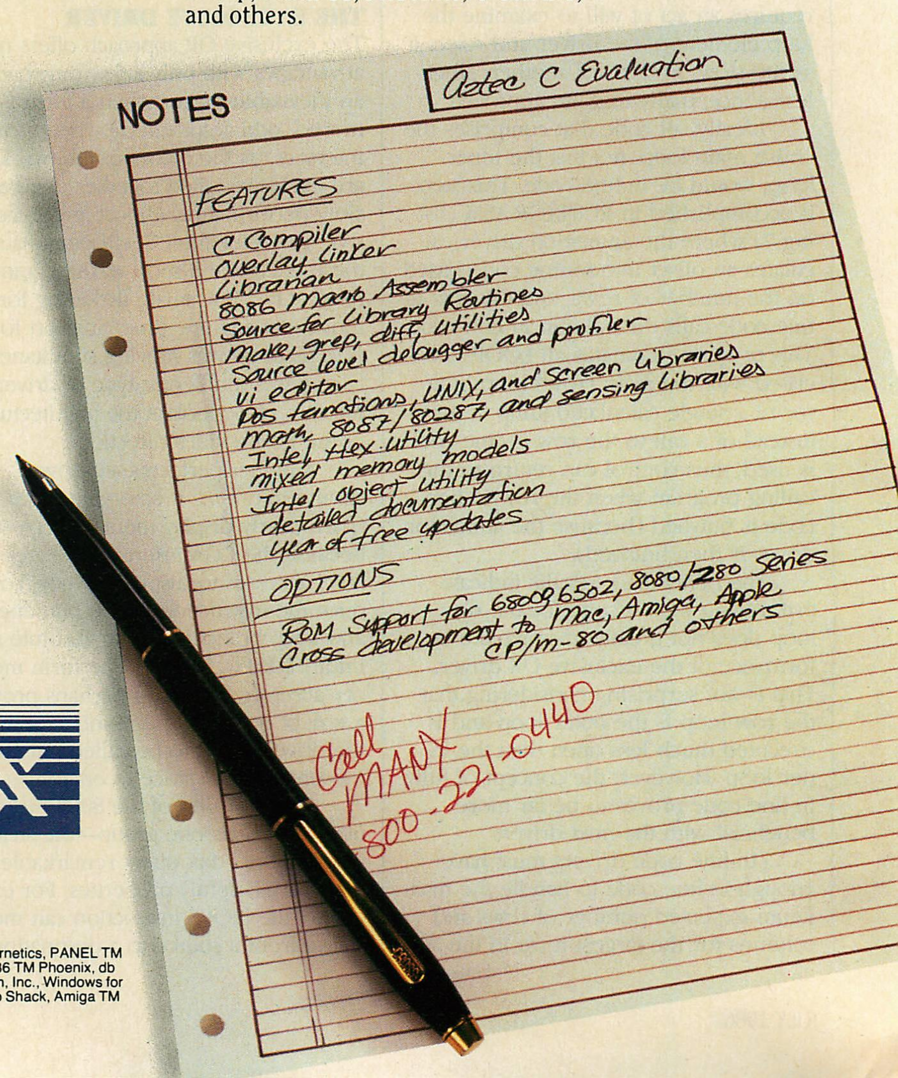

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next REP MOVSB during the operation of the current REP MOVSB.

This driver also minimizes memory accesses—one read and one write per form byte (only one write when erasing) is an absolute minimum. The XOR instruction in the exclusive-OR driver actually performs two memory accesses, one to read the display memory byte and another to write back the modified value; worse, those two accesses are display memory accesses, and as a result are especially slow. The byte-move driver performs just one display memory access per form byte.

To this point, branching has been reduced to a minimum, and because the string instructions perform memory access as rapidly as is possible with the 8088, memory access has been optimized: in short, most of the criteria for a superior driver have been met. Listing 9 (BYTBENCH.ASM) is the benchmark program of listing 3 modified to call the byte-move **form_driver** and **erase_form_driver** routines. (Note that the code for drawing the initial forms is not required in this version of the benchmark; the byte-move erase routine unconditionally erases an area of the screen, unlike the exclusive-OR driver, which could erase only a form that already had been drawn.) With the byte-move driver of listing 8, the benchmark time is reduced to a mere 10 seconds—this speed improvement over the original exclusive-OR driver is greater than the improvement derived from converting the exclusive-OR driver from C to assembly language.

An added benefit of this driver is that no color side effects result when forms intersect. The most recently drawn form simply appears to be in front of the other form. However, if two forms overlap for an extended period of time, some flicker may become evident as each in turn is redrawn and appears to be in front.

The bad news about the byte-move driver is that it lacks the reversibility of the exclusive-OR driver. Whenever a form is moved, a blank is left where it was erased. This is not a serious problem if all forms on the screen are animated. In this case, the main program can redraw all the forms frequently, and any gaps left after form erasure will vanish quickly enough to be unnoticeable to the human eye.

One of the forms animated by the benchmark program is redrawn repeatedly at the same location. This is one way to provide a background with a byte-move driver. As long as the background area to be maintained is not too large, redrawing it frequently like any other form is a good approach. This also makes it easy for the user to modify the background periodically by simply changing the form that is drawn. For example, a twinkling star can be drawn as a cyclic succession of several slightly different star forms.

If the picture has a static background that is not redrawn frequently, the byte-move driver introduces serious complications. Some scheme must be designed that allows intelligent redrawing of the background as each form is moved. (One such approach to solving this problem is discussed later.)

SELF-ERASURE

The byte-move driver is made even more effective with self-erasure. Actually, this driver is exactly the same as the last byte-move driver—the difference lies in its application. For this driver, each form must contain a blank fringe around it equal in size to the greatest move that the form will make. A normal application is to assume that the form moves a maximum of four pixels horizontally and two pixels vertically at any one time. (Larger moves can appear jerky, so this is a reasonable assumption.) Thus each form would have four pixel's worth of horizontal blanking and two pixel's worth of vertical blanking built into its movement.

As long as the background area to be maintained is not too large, redrawing it frequently like any other form is a good approach.

This eliminates the need to erase a form when it is moved: the erasure is automatic. Moreover, no flicker appears because the form's erasure and redrawing are simultaneous. The end result is a graphics driver that is slightly less than two times faster than even the original byte-move driver (faster because the erasure step was eliminated, but only somewhat because the extra fringe bytes must be drawn), and which produces smooth animation.

Although this driver has the same drawbacks as any byte-move driver (and a few more of its own), it is extremely fast and looks very good. Listing 10 (BYTFRNGE.ASM) is the benchmark program for the automatic erasure fringe driver. (The driver itself is the same as that in listing 8; in the benchmark program, the forms are changed to include the fringe and the code for drawing the initial forms and for erasing the forms is no longer needed.) The benchmark for this driver clocks in at a flicker-free 8 seconds, but this number does not tell the whole story. To see the real difference, run the original exclusive-OR benchmark of listings 1 and 3 and the byte-move benchmark of listings 8 and 10 one after the other to appreciate how much of an improvement in animation effect a high-performance driver makes.

One unfortunate characteristic of this byte-move driver is that the blank fringe around the form is visible when forms intersect. (See photo 2 for an illustration of this problem.) However, this is less distracting than exclusive-OR driver color effects and scarcely noticeable if the fringe is narrow.

The byte-move driver can be optimized further (beyond what is covered in this article). The form of the driver shown in listings 8 and 10 is still too general purpose. The entire erasure fringe must be drawn every time a form is moved; this wastes time and prevents forms from getting closer to the edge of the screen than the distance of their maximum move because the erasure fringe would go off the edge of the screen. The solution is to have four drivers, one for each direction of movement (more if diagonal moves are required). Each driver would be optimized to erase only the area vacated by the moving form. Alternatively, each form could have four versions, one for each direction of movement, and the main program could call the driver with the appropriate form for the direction of movement needed.

A BETTER BACKGROUND

The only serious problem with byte-move drivers is preserving the background. One solution introduces additional complexity to animation program design; but it maintains the speed advantages and smooth animation of byte-move drivers while allowing use of a static background.

The static background may be stored in a 16KB buffer within the program in the form in which it would be stored in display memory. Thus, the bytes for the erasure fringe would come from the background buffer, rather than being zero bytes. This could be done by the byte-move driver, or the main program could call a separate

driver to redraw the appropriate fringe from the background buffer after the form has been moved. In any case, calculation of the background source addresses would be very simple because a one-to-one mapping would be present between background buffer offsets and display memory offsets.

A buffer of 16KB may seem a lot of memory to use for a background, but this approach produces an excellent blend of speed, smooth animation, and background preservation. Besides, as mentioned above, memory is cheap (and the 8088 can address a lot of it), so it should be used to compensate for the limitations of the PC when possible.

ANIMATED DETAILS

All of the drivers discussed are limited to a movement increment of four pixels horizontally because the drivers work with a byte at a time, but this is not an inherent limitation of the drivers. The trick to pixel-aligning forms is to have three additional rotations of each form, one for each pixel alignment within the display memory byte, with the calling program passing the correct form for the desired pixel alignment to the driver. All of the rectangles drawn will still be byte-aligned, but each form will be positioned within its rectangle so that it appears at the correct pixel alignment.

A driver that supports pixel alignment via multiple form rotations also supports simple horizontal internal animation. Internal animation is a process whereby the appearance of an object changes as it moves, giving the object the appearance of being alive. For example, a creature's mouth might chomp, a rocket's exhaust might flare, and a humanoid's legs might walk.

Internal animation can be accomplished in many ways, but by far the simplest is to assign each of four internally animated versions of an object to one of the four pixel-aligned figures. Then the figure will automatically display internal animation as it moves horizontally in increments of one pixel.

For vertical motion, the calling program must cycle among the internal animation images to produce internal animation. This technique may be applied to horizontal motion as well for complex internal animation. Different forms can be sent to the driver by the main program for each direction of motion, so that, for example, a human figure will appear to walk right or left while moving horizontally and climb up or down while moving vertically.

Remember that the 8088 is considerably more efficient at accessing memory a word at a time than a byte at a time, requiring only four extra cycles per memory access for the added byte. When drawing medium- and large-sized forms, the drivers would benefit from the efficiency of word, rather than byte, operation. These byte-move drivers use byte memory accesses because for word-move drivers (using MOVSW instead of MOVSB) all forms must be a multiple of a word in width. For this application, a requirement that all forms be a multiple of eight pixels in width was too great a limitation. For exclusive-OR drivers, however, there is no compelling reason not to use word drivers for larger forms; any extra byte per row needed to pad a form to an even number of bytes can always be set to zero and thus have no effect.

For programmers working extensively with animation drivers, it is advisable to write a form editor that allows form modification on a dot-by-dot basis and then stores them to disk in the data structure required by the specific driver, preferably with pixel-aligned rotations supported as well. The program then can load the forms and use them. This is far easier than defining forms in hexadecimal with DB statements (as was the case in this article).

> *Most importantly, no* best *driver exists. Optimization of animation drivers for the IBM PC is an application-specific process.*

In addition, remember that these optimizations were effected on the instruction timings and architecture of the 8088 and the IBM CGA. The 80286 has a different set of instruction timings, and its treatment would be different. The 80286 LOOP instruction, for example, takes 8 cycles, not 17.

A GOOD DRIVER

The animation drivers examined provide the prospective user a range of trade-offs among speed, ease of use, background preservation, memory requirements, and flexibility. None is perfect; but after all, the IBM PC and the CGA are far from perfect as vehicles for animation; however, it should be possible to customize one of these drivers to meet a given application.

The byte-move approach seems the only one capable of supporting good animation of multiple objects on the IBM PC. This is not to say that byte-move, or any of these drivers in particular, is the best possible route. Assembly language optimizations are elusive, and a programmer can examine a code fragment many times and keep finding ways to pare a few cycles here and there. A more important point, however, is that no *best* driver exists. In fact, some applications may call for using exclusive-OR and byte-move drivers at the same time, as each is best for a different part of the overall animation. Optimization of animation drivers for the PC is an application-specific process, because every cycle counts and every application lends itself best to a different animation structure. The techniques introduced here are meant as tools, not final answers, for the programmer to integrate into his applications as he deems appropriate. They are also meant to encourage the programmer to examine the 8088 architecture to find his own unconventional, but effective approaches to coding animation problems.

(One trial application called for moving hundreds of single dots simultaneously at a high speed, while animating dozens of larger forms as well. No driver could be devised to move the dots without slowing the program to a crawl. Finally, the actual display memory addresses of the dots were stored in an array, and the address of each dot was incremented by the display memory offset to its next position each time it moved; the exclusive-OR was performed directly from the stored screen offset value. Inflexible and highly application-specific, true, but it was the best answer to the application's needs.)

It is indeed possible to do better with less, in a different way. A good programmer knows how to apply standard techniques to a tough problem and produce a working solution. An exceptional programmer realizes that in such cases programming transcends mere implementation techniques, and he applies his knowledge and skills to produce a melding of software and hardware that performs the required task in the most effective way possible. In an arena where only results count, the flexibility of the human mind itself is often the final bottleneck.

Michael Abrash is a senior software engineer for Tseng Laboratories in Pennsylvania. Dan Illowsky is president of Funtastic. Together and separately they have written video games for the IBM PC and Apple II.

LISTING 1: STANDXOR.ASM

```
;Standard XOR graphics driver for putting rectangular images into
; the Color/Graphics Adapter's medium-resolution memory map.
;
; Note: all registers preserved.
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        public  form_driver
;
display_width   db      80
line_counter    db      ?
;
form_driver proc near
        push    ax      ;preserve all general registers
        push    bx
        push    cx
        push    dx
        push    si
        push    di
;
        shr     bl,1    ;are we starting in top or bottom 8K bank?
                        ; also divides row by 2 to compensate for
                        ; odd/even bank arrangement
        jc      starts_in_second_8k_bank
        sub     di,di   ;even lines start in first 8K bank
        jmp     short calculate_row_offset
starts_in_second_8k_bank:
        mov     di,2000h ;odd lines start in second 8K bank
calculate_row_offset:
        mov     al,[display_width]
        mul     bl      ;find the offset of top line of image
        add     di,ax   ; relative to start of 8K bank
        add     di,cx   ;ES:DI now points to byte at which to put
                        ; the image's upper left corner
        mov     al,[si] ;get the height of the image
        inc     si      ;point to form width
        mov     [line_counter],al  ;store count of lines to draw
        mov     dl,[si] ;get the width of the image in bytes
        sub     dh,dh   ;make 16 bit value
        inc     si      ;point to start of form bytes
;
next_line:
        mov     cx,dx     ;set the number of bytes/line for form
        push    di        ;preserve offset of start of line
next_column:
        mov     al,[si]   ;get this image byte
        inc     si        ;point to the following image byte
        xor     es:[di],al ;exclusive-OR it into screen memory
        inc     di        ;point to next screen memory position
        loop    next_column ;loop for next byte on line
        pop     di        ;get back offset of start of this line
        cmp     di,2000h       ;which 8K bank is next line in?
        jb      next_line_in_second_8k
        sub     di,2000h-50h  ;point start of next line in 1st 8K
        jmp     short count_down_lines
next_line_in_second_8k:
        add     di,2000h      ;point start of next line in 2nd 8K
count_down_lines:
        dec     [line_counter] ;count down number of lines
        jne     next_line      ;jmp if any lines left
                               ;if not, restore registers and
        pop     di             ; return to calling program
        pop     si
        pop     dx
        pop     cx
        pop     bx
        pop     ax
        ret
;
form_driver endp
one     ends
        end
```

LISTING 2: CXOR.C

```
/* This program benchmarks the C exclusive-OR driver */
#include <stdio.h>
#include <dos.h>
/* Eight objects will be moved on the screen 700 times */
#define NUM_ITERATIONS  700
#define NUM_OBJECTS     8
/*  The position, screen boundaries, and distance to move the objects
    each iteration are stored below */
int row[NUM_OBJECTS]                = {100,100,100,100,100,100,100,100};
int column[NUM_OBJECTS]             = { 32, 32, 32, 32, 32, 32, 32, 32};
int row_increment[NUM_OBJECTS]      = { -2,  2,  0, -2,  0,  0, -2,  2};
int column_increment[NUM_OBJECTS]   = {  1,  1,  0, -1,  1, -1,  0, -1};
int left_margin[NUM_OBJECTS]        = {  0,  0,  0,  0,  0,  0,  0,  0};
int right_margin[NUM_OBJECTS]       = { 76, 74, 72, 70, 70, 72, 74, 76};
int top_margin[NUM_OBJECTS]         = {  0,  0,  0,  0,  0,  0,  0,  0};
int bottom_margin[NUM_OBJECTS]      = {194,184,174,164,164,174,184,194};
/* Four rectangular forms, f0,f1,f2 & f3 are defined below. Each form
   starts with the number of lines and rows in the image. These two
   bytes are then followed by the image which will be placed into
   the screen memory map. */
unsigned char f0[] = { 6, 4,
        0xf0, 0x0f, 0xf0, 0x0f,
        0xf0, 0x3f, 0xfc, 0x0f,
        0xff, 0xff, 0xff, 0xff,
        0xf0, 0xff, 0xff, 0x0f,
        0xf0, 0x3f, 0xfc, 0x0f,
        0xf0, 0x0f, 0xf0, 0x0f};
unsigned char f1[] = { 16, 6,
        0x55,  0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55,
        0x55,  0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55,
        0x55,  0x55, 0x55, 0x55,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
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        0xff, 0xff, 0xff, 0xff,
        0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa,
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        0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x55,
        0x55, 0x55, 0x55, 0x55};
unsigned char f2[] = { 26, 8,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
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        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
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        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
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        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff,
        0xff, 0xaa, 0xaa, 0x55, 0x55, 0xaa, 0xaa, 0xff};
unsigned char f3[] = { 36, 10,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
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        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xff, 0xff,
```

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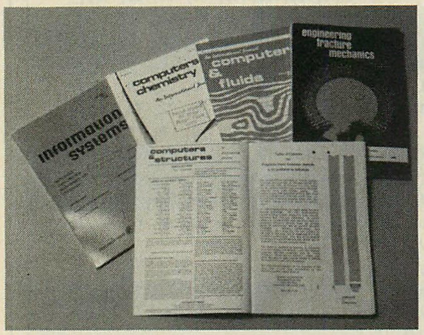

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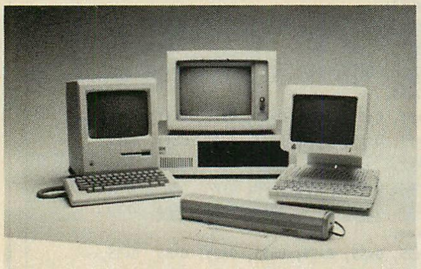

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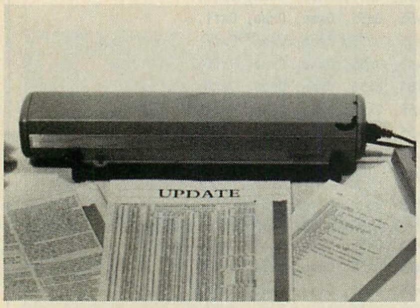

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```
        0xff, 0xff, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xaa, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0x55, 0x55, 0x55, 0x55, 0xaa, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0x55, 0x55, 0x55, 0x55, 0xaa, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0x55, 0x55, 0x55, 0x55, 0xaa, 0xff, 0xff,
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        0xff, 0xff, 0xaa, 0x55, 0x00, 0x00, 0x55, 0xaa, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0x55, 0x00, 0x00, 0x55, 0xaa, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0x55, 0x00, 0x00, 0x55, 0xaa, 0xff, 0xff,
        0xff, 0xff, 0xaa, 0x55, 0x00, 0x00, 0x55, 0xaa, 0xff, 0xff,
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        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
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        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff,
        0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff};
/* The list of forms to be used for the eight objects follows */
unsigned char *form_address[NUM_OBJECTS]
        = { f0, f1, f2, f3, f3, f2, f1, f0};

main()
{
        struct reg inregs, outregs;
        register int i, j;

/* set 320x200 graphics mode */
        inregs.r_ax = 4;
        intcall(&inregs,&outregs,0x10);
/* put forms on screen for the first time */
        j = NUM_OBJECTS - 1;
        do {
            form_driver(row[j],column[j],form_address[j]);
        } while ( j-- != 0 );
/* for # of iterations, move each object in turn */
        i = NUM_ITERATIONS - 1;
        do {
            j = NUM_OBJECTS - 1;
            do {
                form_driver(row[j],column[j],form_address[j]);
                if ( row[j] <= top_margin[j] || row[j]
                        >= bottom_margin[j] )
                    row_increment[j] *= -1;
                if ( column[j] <= left_margin[j] || column[j]
                        >= right_margin[j] )
                    column_increment[j] *= -1;
                row[j] += row_increment[j];
                column[j] += column_increment[j];
                form_driver(row[j],column[j],form_address[j]);
            } while ( j-- != 0 );
        } while ( i-- != 0 );
/* set 80x25 text mode before returning to DOS */
        inregs.r_ax = 2;
        intcall(&inregs,&outregs,0x10);
}

/* exclusive-OR driver */
form_driver(r,c,fax)
/* r and c are the row and column at which to put object.
   r is the line number and can range from 0 - 199. 0 is the top line.
   c is the column byte number and can range from 0 - 79; 0 leftmost.
   fax is a pointer to the form to be XORed into screen memory */
int r, c;
unsigned char *fax;
{
        register int offset;
        register unsigned char *fa;
        int toffset, i, j, k;

        fa = fax;
        if ( ( r & 1 ) == 0 )
            offset = ( r >> 1 ) * 80 + c;
        else
            offset = ( r >> 1 ) * 80 + c + 0x2000;
        i = *fa++;
        j = *fa++;
        do {
            toffset = offset;
            k = j;
            do {
                putbyt(*fa++,offset++);
            } while ( --k != 0 );
            if ( toffset < 0x2000 )
                offset = toffset + 0x2000;
            else
                offset = toffset - 0x1fb0;
        } while ( --i != 0 );
}
```

LISTING 3: XORBENCH.ASM

```
;This program benchmarks exclusive-OR drivers.
;Link the XOR form_driver module to this program.
;
stack   segment para stack 'STACK'
        db      512 dup(0)
stack   ends
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        extrn   form_driver:near
;
iteration_count  dw     0
;
;Lists describing image, location, and motion of 8 objects.
;
form_address     dw  f0, f1, f2, f3, f3, f2, f1, f0 ;pointers to form
                                                    ; byte strings for
                                                    ; each object
highest_object_pointer equu (($-form_address)-2)    ;the index for the
                                                    ; last object in
                                                    ; these lists
                 ;in scan lines (0 - 198):
row              dw 100,100,100,100,100,100,100,100
                 ;in bytes (0 - 79):
column           dw  32, 32, 32, 32, 32, 32, 32, 32
                 ;in scan lines (0 - 198):
row_increment    dw  -2,  2,  0, -2,  0,  0, -2,  2
                 ;in bytes (0 - 79):
column_increment dw   1,  1,  0, -1,  1, -1,  0, -1
                 ;byte number on line (0-79):
left_margin      dw   0,  0,  0,  0,  0,  0,  0,  0
                 ;byte number on line (0-79):
right_margin     dw  76, 74, 72, 70, 70, 72, 74, 76
                 ;line number (0 - 198):
top_margin       dw   0,  0,  0,  0,  0,  0,  0,  0
                 ;line number (0 - 198):
bottom_margin    dw 194,184,174,164,164,174,184,194
;
;Form byte structures, as follows:
;       byte 1: # of scan lines in forms.
;       byte 2: # of bytes per scan line of form.
;       byte 3: first byte of image, followed by rest of bytes
;               forming image, with bytes for top scan line,
;               left to right, first, second scan line next,
;               and so on.
;
f0      db 6,4
        db 0f0h,00fh,0f0h,00fh
        db 0f0h,03fh,0fch,00fh
        db 0ffh,0ffh,0ffh,0ffh
        db 0f0h,0ffh,0ffh,00fh
        db 0f0h,03fh,0fch,00fh
        db 0f0h,00fh,0f0h,00fh
```

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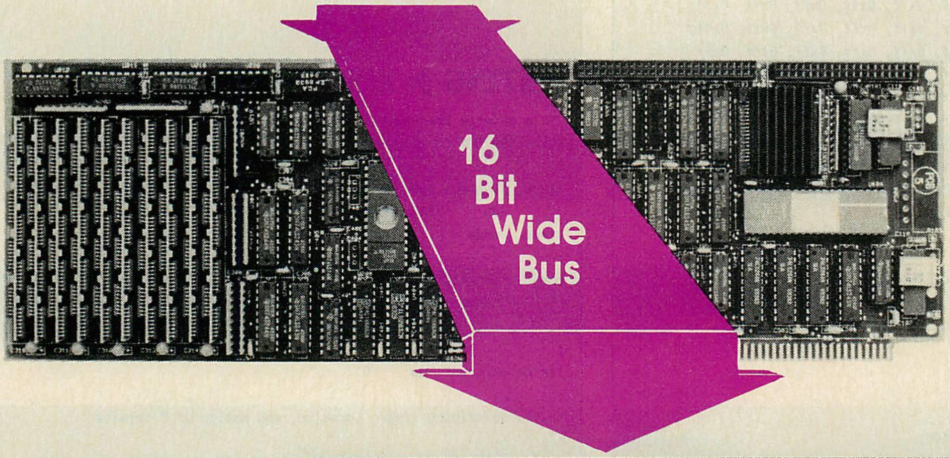

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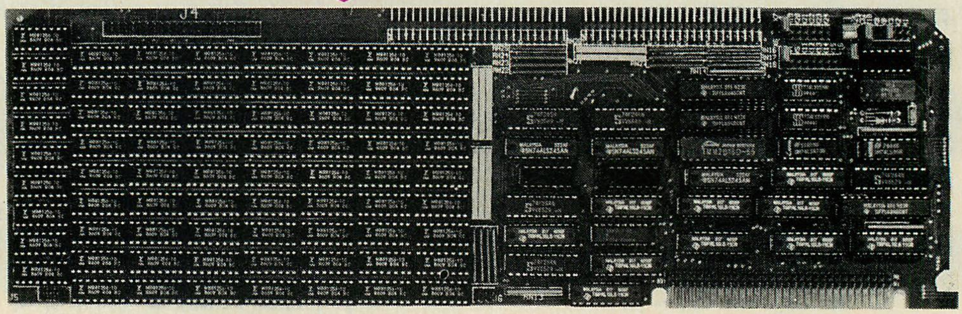

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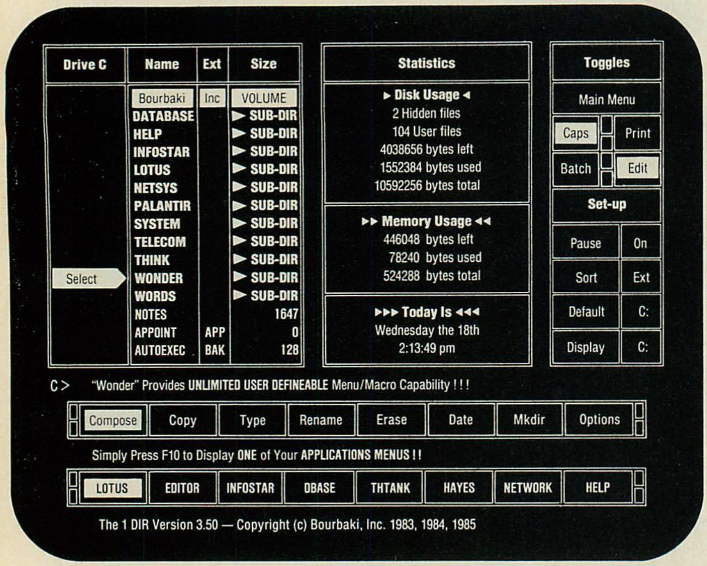
CIRCLE NO. 124 ON READER SERVICE CARD

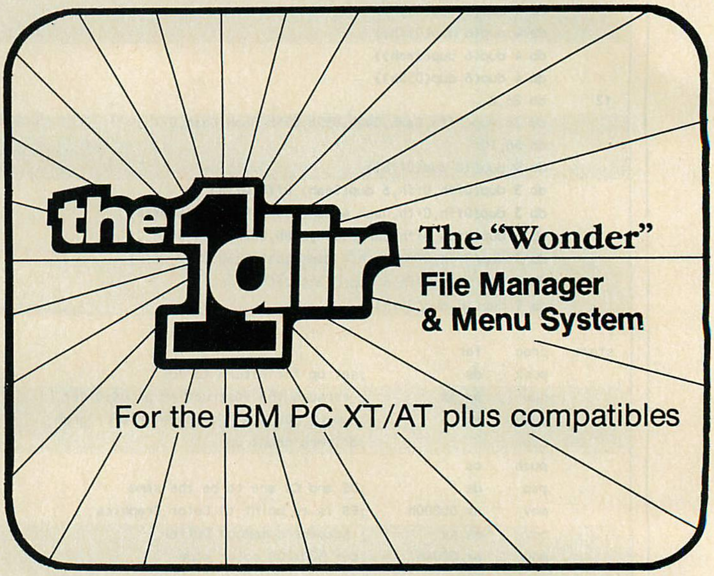
```
f1      db 16,6
        db 4 dup(6 dup(055h))
        db 4 dup(6 dup(0ffh))
        db 4 dup(6 dup(0aah))
        db 4 dup(6 dup(055h))
f2      db 26,8
        db 26 dup(0ffh,0aah,0aah,055h,055h,0aah,0aah,0ffh)
f3      db 36,10
        db 9 dup(10 dup(0ffh))
        db 3 dup(0ffh,0ffh,6 dup(0aah),0ffh,0ffh)
        db 3 dup(0ffh,0ffh,0aah,4 dup(055h),0aah,0ffh,0ffh)
        db 6 dup(0ffh,0ffh,0aah,055h,000h,000h,055h,0aah,0ffh,0ffh)
        db 3 dup(0ffh,0ffh,0aah,4 dup(055h),0aah,0ffh,0ffh)
        db 3 dup(0ffh,0ffh,6 dup(0aah),0ffh,0ffh)
        db 9 dup(10 dup(0ffh))
;
start   proc    far
        push    ds              ;set up for return to DOS
        sub     ax,ax           ; through the instruction at DS:0 set
        push    ax              ; up by DOS when it loads this program
        cld                     ;drivers count up
        push    cs
        pop     ds              ;DS and CS are to be the same
        mov     ax,0b800h       ;ES is to point to Color Graphics
        mov     es,ax           ; Adapter's memory buffer
        mov     ax,0004h        ;set 320x200 color mode
        int     10h             ;
;
;Start by drawing all the images at their starting locations
;
        mov     si,highest_object_pointer   ;start at last object
next_initial_draw:
        push    si                      ;save the object index
        mov     bx,[si+row]             ;get the line at which to put
                                        ; this object
        mov     cx,[si+column]          ;get the column for this object
        mov     si,[si+form_address]    ;get the address of the
                                        ; object's image
        call    form_driver             ;put image to screen memory
        pop     si                      ;restore the object index
        sub     si,2                    ;point to next object to draw
        jns     next_initial_draw       ;if not done draw next object
;
;Set number of times to move objects
;
        mov     [iteration_count],700   ;number of times to repeat
                                        ; move loop
;
;For each iteration, move each object in turn by erasing it,
; moving it one increment, and drawing it at the new position.
;
next_iteration:
        mov     si,highest_object_pointer ;start at last object
;
;Move each object in turn.
;
move_next_object:
;
;Erase the object at its present position.
;
        push    si                      ;exclusive-ORing an existing
        mov     bx,[si+row]             ; image with itself
        mov     cx,[si+column]          ; effectively erases it
        mov     si,[si+form_address]    ;
        call    form_driver             ;
        pop     si                      ;
;
;Advance the object's row and column and adjust increments
; so the object remains within its boundaries.
;
;If adding the row increment to the row would place it outside
; its margins...
;
        mov     ax,[si+row]             ;test the new line position
        add     ax,[si+row_increment]   ; to see if it goes outside
        cmp     ax,[si+top_margin]      ; its limit
        jb      negate_row_increment    ;if outside negate increment
        cmp     ax,[si+bottom_margin]   ; so that it will move towards
        jbe     test_column_increment   ; its other limit
;
;...then make the row increment negative if positive and
; positive if negative.
;
negate_row_increment:
        neg     [si+row_increment]      ;make it move in other direction
;
;If adding the column increment to the column would place it
; outside its margins...
;
test_column_increment:
        mov     ax,[si+column]              ;if the column for the object
        add     ax,[si+column_increment]    ;would go outside its left or
        cmp     ax,[si+left_margin]         ; right limits, then negate
        jb      negate_column_increment     ; its increment so that it
        cmp     ax,[si+right_margin]        ; will move in the opposite
        jbe     add_increments              ; direction
;
;...then make the column increment negative if positive and
; positive if negative.
;
negate_column_increment:
        neg     [si+column_increment]       ;set to move in opposite
                                            ; direction
;
;Add the increments to the row and column to arrive at the
; object's next position.
;
add_increments:
        mov     ax,[si+row_increment]       ;calculate the next line
        add     [si+row],ax                 ; position and store it
        mov     ax,[si+column_increment]    ;calculate the next column
        add     [si+column],ax              ; position and store it
;
;Draw the object at the new location.
;
        push    si                          ;save this object index
        mov     bx,[si+row]                 ;find line and column no. at
        mov     cx,[si+column]              ; which to place the object
        mov     si,[si+form_address]        ;find addr. of object's form
        call    form_driver                 ;put object's image into screen
        pop     si                          ;restore the object index
;
        sub     si,2                        ;point to next object to move
        jns     move_next_object            ; if not done jmp to move it
;
        dec     [iteration_count]           ;count down number of times to
        jnz     next_iteration              ; move all the objects
;
;Reset the mode to 80x25 color text mode.
;
        mov     ax,0003h                    ;before returning to DOS, set
        int     10h                         ; screen to 80x25 text mode
;
;Return to DOS.
;
        ret                                 ;return though instruction at
                                            ; start of PSP set up by DOS
start   endp
one     ends
        end     start
```

LISTING 4: DRIVECXOR.ASM

```
;Assembly language subroutine for C exclusive-OR driver,
; in format required by Mark Williams C compiler.
;Exclusive-ORs byte at color display offset.
;
; Input:
;       parm 1 - byte to exclusive-OR.
;       parm 2 - offset to exclusive-OR byte at.
;
; Output: none
;
CGROUP  GROUP   CODE
;
;Parameter layout for use in addressing the 2 parameters on the stack.
;
dyns    struc
old_bp  dw      ?
```

Nine Reasons to "Wonder"





The "Wonder" screen acts as a sophisticated instrument panel to guide even the most novice users through the intricacies of program selection and file management. Its' menuing/macro functions and point and shoot management expedite the normally tedious routines of any product demonstration.

1 "Wonder" is easy to use. Many Corporate Training Centers and Independent consultants across the country use "Wonder" to soothe initial fears and pave the way to increased productivity.

As Tim Daneliuk, Contributing Editor for PC Products wrote,

*"Quite simply **1dir** works flawlessly . . . **1dir** is a well conceived and implemented product that is whole heartedly recommended for virtually anyone who uses their P.C. often. It provides an easy-to-use doorway into DOS and is flexible enough for novice and expert alike."*[1]

2 "Wonder" is easy to install. Although "Wonder" can be programmed to perform countless time saving tasks, it is not unreasonable for a novice user to create a basic system in less than an hour.

3 "Wonder" helps sell systems. By expediting machine operation and routine maintenance, "Wonder" puts the focus on practical applications which is the real reason that people buy computers in the first place.

4 "Wonder" is ideally suited for the trend toward hard disk technology. "Wonder" is licensed by more hard disk manufacturers than any other program of its type, and many dealers sell "Wonder" with every hard disk system. As Corporate Training Specialist for Micro D., Mr. Don Kenny writes,

*"**1dir** . . . provides the most logical system I've ever seen for managing hard disk files."*[2]

[1]PC Products, 8/85: The 1dir of DOS, Tim Daneliuk, Contributing Editor.
[2]Published letter to PC Week editors, 7/30/85.
[3]PC 12/85: Taming Your Hard Disk The Easy Way: Part 2

5 The demand for "Wonder" is on the rise. Rave reviews in PC, Infoworld, Business Software, PC Products, Compute and others have increased public awareness and established **1dir** as an industry standard. In an article entitled "Taming Your Hard Disk The Easy Way" Phil Wiswell of PC concludes

*". . . **1dir** does indeed spell WONDER."*[3]

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CIRCLE NO. 247 ON READER SERVICE CARD

```
old_ds  dw      ?
retn    dw      ?
p1      dw      ?
p2      dw      ?
dyns    ends
;
code    segment byte public 'CODE'
        public  putbyt_
        assume  cs:cgroup
;
putbyt_ proc    near
        push    ds
        push    bp
        mov     bp,sp
        mov     al,byte ptr [bp].p1  ;get byte to xor into display RAM
        mov     bx,0b800h
        mov     ds,bx           ;point segment to color display RAM
        mov     bx,[bp].p2      ;get screen offset to xor byte at
        xor     [bx],al         ;xor byte into display RAM
        pop     bp
        pop     ds
        ret
putbyt_ endp
code    ends
        end
```

LISTING 5: OPTXOR.ASM

```
;Optimized XOR graphics driver for putting rectangular images into
; the Color/Graphics Adapter's medium-resolution memory map.
;
; Note: AX,BX,CX,DX,BP,SI,DI destroyed.
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        public  form_driver
;
form_driver proc near
        mov     di,[bx+even_line_screen_offset_table]  ;find offset of
                                                        ; top line of image
        add     di,cx     ;ES:DI now points to byte at which to put
                          ; the image's upper left corner
        lodsb             ;get the height of the image
        shr     al,1      ;divide by 2 to arrive at number of even/odd
                          ; line pairs in the image
        mov     ah,al     ;store count in AH
        lodsb             ;get the width of the image in bytes
        mov     bl,al     ;put width in BL
        sub     bh,bh     ;make width a 16 bit value
        mov     bp,2000h  ;calculate the amount to add after even scan
        sub     bp,bx     ; lines are drawn to get to address of the
                          ; next scan line
        mov     dx,1fb0h  ;calculate amount to subtract after odd scan
        add     dx,bx     ; lines are drawn to get to address of the
                          ; next scan line
;
next_two_lines:
        mov     cx,bx     ;set the number of bytes/line for the form
next_column_for_even_row:
        lodsb             ;get the next image byte
        xor     es:[di],al ;exclusive-OR it into screen memory
        inc     di        ;point to next screen memory position
        loop    next_column_for_even_row   ;loop for next byte
                                           ; on even line
        add     di,bp     ;calculate address to start next line of image
        mov     cx,bx     ;reset the number of bytes/line for an odd row
next_column_for_odd_row:
        lodsb             ;get the next image byte from the form
        xor     es:[di],al ;exclusive-OR onto screen
        inc     di        ;advance screen memory pointer
        loop    next_column_for_odd_row ;loop for nxt byte on odd line
        sub     di,dx     ;calculate the address to start next line
                          ; of image--next line will be an even line
        dec     ah        ;count down number of line pairs
        jne     next_two_lines ; jmp if any even/odd line pairs left
        ret               ; if not, return to calling program
;
;This table is used to find the offset of an even scan line in
; the memory map of the color graphics adapter in medium res mode.
;
even_line_screen_offset_table label word
x=0
        rept    100       ;there are 100 even lines
        dw      x*50h     ; each is 50h (80 decimal) long
x=x+1
        endm
;
form_driver endp
one     ends
        end
```

LISTING 6: INLINXOR.ASM

```
;Column inline code XOR graphics driver for putting rectangular
; imagesinto the CGA's medium-resolution memory map.
;
; Note: AX,BX,CX,DX,BP,SI,DI destroyed.
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        public  form_driver
;
form_driver proc near
        mov     di,[bx+even_line_screen_offset_table]  ;find offset of
                                                        ; top line of image
        add     di,cx     ;ES:DI now points to byte at which to put
                          ; the image's upper left corner
        lodsb             ;get the height of the image
        xor     ah,ah     ;make height into 16 bit value
        shr     ax,1      ;divide by 2 to arrive at number of even/odd
                          ; line pairs in the image
        mov     cx,ax     ;store count in CX
        lodsb             ;get the width of the image in bytes
        mov     bp,2000h  ;calculate the amount to add after even scan
        sub     bp,ax     ; lines are drawn to get to address of the
                          ; next scan line
        mov     dx,1fb0h  ;calculate amount to subtract after odd scan
        add     dx,ax     ; lines are drawn to get to the address of
                          ; the next scan line
        mov     bx,ax     ;number of columns in image
        shl     bx,1      ;convert into word table index
        mov     bx,[bx+column_inline_vector_table-2]
;
;Code for calculating the memory address to start each line of the
; image, and calling the inline code which exclusive-ORs a line of the
; image into the screen
;
next_two_lines:
        call    bx        ;BX holds address of inline columns code
        add     di,bp     ;calculate address to start next line of image
        call    bx        ;process image for odd scan line
        sub     di,dx     ;calculate address to start next line of image
                          ; the next line will be an even line
        loop next_two_lines ;loop if any even/odd line pairs left
        ret                 ; if not, return to calling program
;
;Inline code for XORing a line of the image into the screen
;
clabel  macro   x         ;this macro is used to label the inline code
cline&x&:                 ; entry points for number of columns to XOR
        endm              ;
;
x=10                      ;this code can handle an image up to
        rept    10        ; 10 bytes wide
        clabel  %x        ;put in label for entry based on number of
                          ; bytes in a column
        lodsb             ;get the next byte from the object's image
        xor     es:[di],al ; and XOR it with the value now at the
                          ; screem position.
        inc     di        ;point to next image byte in object's form
x=x-1                     ;adjust label number
        endm
        ret               ;this return is executed at the end of
                          ; every line
;
;This table is used as an indirect address for jumping into
; the inline code for exclusive-ORing columns.
;
```

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CIRCLE NO. 190 ON READER SERVICE CARD

```
column_inline_vector_table label word    ;there is no entry point for
                                         ; 0 lines. Starting at 2
                                         ; eliminates the need to
                                         ; store a dummy entry point
                                         ; address
column_entry_address   macro   x         ;this macro is used to
                dw      cline&x&         ; generate the labels
                endm                     ; correspinding to the inline
                                         ; code entry points
;
x=1
        rept    10
        column_entry_address    %x
x=x+1
        endm
;
;This table is used to find the offset of an even scan line in
; the memory map of the color graphics adapter in medium res mode.
;
even_line_screen_offset_table label word
x=0
        rept    100     ;there are 100 even lines
        dw      x*50h   ; each is 50h (80 decimal) long
x=x+1
        endm
;
form_driver endp
one     ends
        end
```

LISTING 7: RCINXOR.ASM

```
;Full row & column inline code XOR graphics driver for putting
; rectangular images into the Color/Graphics Adapter's
; medium-resolution memory map.
;
; Note: AX,BX,CX,DX,BP,SI,DI destroyed.
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        public  form_driver
;
form_driver proc near
        mov     di,[bx+even_line_screen_offset_table]  ;find offset of
                                                       ; top line of image
        add     di,cx    ;ES:DI now points to byte at which to put
                         ; the image's upper left corner
        lodsb            ;get the height of the image
        xor     ah,ah    ;make height a word value for calculations
        mov     bx,ax    ;store height in BX
        lodsb            ;get the width of the image in bytes
        mov     bp,2000h ;calculate the amount to add after even scan
        sub     bp,ax    ; lines are drawn to get to the address of
                         ; the next scan line
        mov     dx,1fb0h ;calculate amount to subtract after odd scan
        add     dx,ax    ; lines are drawn to get to the address of
                         ; the next scan line
        mov     cx,[bx+inline_height_vector_table-2] ;-2 because there
                                                     ; is no 0 lines entry point
        mov     bx,ax    ;number of columns in image
        shl     bx,1     ;convert into word table index
        mov     ax,[bx+column_inline_vector_table-2]
        xchg    ax,cx    ;CX now holds column code &,
                         ; AX the row code address
        jmp     ax       ;jmp to into inline code for height
;
;This table is used to find the offset of an even scan line in
; the memory map of the color graphics adapter in medium res mode.
;
even_line_screen_offset_table label word
x=0
        rept    100     ;there are 100 even lines
        dw      x*50h   ; each is 50h (80 decimal) long
x=x+1
        endm
;
;This is inline code for finding the screen address for each line
; of the image and calling the exclusive-ORing inline code.
;
label   macro   x          ;this macro is used to label the inline code
line&x&:                   ; entry points
        endm
;
;
; inline code for rows
;
x=42                       ;there will be an entry point for each even
                           ; number of lines between 2 and 40. They will
                           ; be labeled "line2", "line4", ... "line40"
        rept    20         ;each repeat handles 2 lines; 1 even, 1 odd
x=x-2                      ;calculate no. of lines for this entry point
        label   %x         ;put in label for entry point

        call    cx         ;CX holds address of inline columns code
        add     di,bp      ;calculate address to start next line of image
        call    cx         ;process image for odd scan line
        sub     di,dx      ;calculate address to start next line of image
        endm               ; the next line will be an even line
        ret
;
;Inline code for XORing a line of the image into the screen
;
clabel  macro   x          ;this macro is used to label the inline code
cline&x&:                  ; entry points for number of columns to XOR
        endm               ;
;
x=10                       ;this code can handle an image up to ten bytes
        rept    10         ; wide
        clabel  %x         ;put in label for entry based on no. of bytes
                           ; in a column
        lodsb              ;get the next byte from the object's image
        xor     es:[di],al ; and XOR it with the value now at the
                           ; screen position.
        inc     di         ;point to next image byte in object's form
x=x-1                      ;adjust label number
        endm
        ret                ;this return is executed at the end of
                           ; every line
;
;This table is used as an indirect address for jumping into
; the inline code for image moving.
;
inline_height_vector_table label word   ;there is no entry point for 0
                                        ; lines. Starting at 2
                                        ; eliminates the need to store
                                        ; a dummy entry point address
entry_address   macro   x               ;this macro is used to generate
                dw      line&x&         ; the labels corresponding to the
                endm                    ; inline code entry points
;
x=2
        rept    20
        entry_address   %x
x=x+2
        endm
;
;This table is used as an indirect address for jumping into
; the inline code for exclusive-ORing columns.
;
column_inline_vector_table label word   ;there is no entry point for
                                        ; 0 lines. Starting at 2
                                        ; eliminates a need to store
                                        ; a dummy entry point address
column_entry_address    macro   x       ;this macro is used to generate
                dw      cline&x&        ; the labels corresponding to the
                endm                    ; inline code entry points
;
x=1
        rept    10
        column_entry_address    %x
x=x+1
        endm
;
;
form_driver endp
one     ends
        end
```

LISTING 8: BYTEMOV.ASM

```
;Byte-move graphics driver for putting rectangular images into
; the Color/Graphics Adapter's medium-resolution memory map.
;
; Note: AX,BX,CX,DX,BP,SI,DI destroyed.
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        public  form_driver,erase_form_driver
;
form_driver proc near
        mov     di,[bx+even_line_screen_offset_table]  ;find the
                                ; offset of the top line of image
        add     di,cx   ;ES:DI now points to byte at which to put
                        ; the image's upper left corner
        lodsb           ;get the height of the image
        xor     ah,ah   ;make height a word value for calculations
        mov     bx,ax   ;store height in BX
        lodsb           ;get the width of the image in bytes
        mov     bp,2000h ;calculate the amount to add after even scan
        sub     bp,ax   ; lines are drawn to get to the address of
                        ; the next scan line
        mov     dx,1fb0h ;calculate the amount to subtract after odd
        add     dx,ax   ; scan lines are drawn to get to the address
                        ; of the next scan line
        jmp     [bx+inline_height_vector_table-2] ;-2 because there
                                ; is no 0 lines entry point
;
;This table is used to find the offset of an even scan line in
; the memory map of the color graphics adapter in medium res mode.
;
even_line_screen_offset_table label word
x=0
        rept    100     ;there are 100 even lines
        dw      x*50h   ; each is 50h (80 decimal) long
x=x+1
        endm
;
;This is inline code for moving the image into the screen memory map.
;
label   macro   x       ;this macro is used to label the inline code
line&x&:                ; entry points
        endm
;
x=42                    ;there will be an entry point for each even
                        ; number of lines between 2 and 40. They will
                        ; be labeled "line2", "line4", ... "line40"
        rept    20
x=x-2                   ;calculate no. of lines for this entry point
        label   %x      ;put in label for entry point
        mov     cx,ax   ;put width of image in bytes in CX to prepare
        rep     movsb   ; for repeated move string on even line
        add     di,bp   ;calc addr. of next line: DI + (2000h-width)
        mov     cx,ax   ;put width of image in bytes in CX to prepare
        rep     movsb   ; for repeated move string on odd line
        sub     di,dx   ;calc addr. of next line: DI - (1fb0h+width)
        endm
        ret
;
;This table is used as an indirect address for jumping into
; the inline code for image moving.
;
inline_height_vector_table label word   ;there is no entry point for
                                ; 0 lines. Starting at 2 eliminates
                                ; the need to store a dummy entry
                                ; point address
entry_address   macro   x       ;this macro is used to generate
                dw      line&x& ; the labels corresponding to the
                endm            ; inline code entry points
;
x=2
        rept    20
        entry_address   %x
x=x+2
        endm
;
form_driver endp
;
;Byte-move graphics driver for erasing rectangular areas of
; the Color/Graphics Adapter's medium-resolution memory map.
;
; Note: AX,BX,CX,DX,BP,SI,DI destroyed.
;
erase_form_driver proc near
        mov     di,[bx+even_line_screen_offset_table]  ;find the
                                ; offset of top line of image
        add     di,cx   ;ES:DI now points to byte at which to put
                        ; the image's upper left corner
        lodsb           ;get the height of the image
        xor     ah,ah   ;make height a word value for calculations
        mov     bx,ax   ;store height in BX
        lodsb           ;get the width of the image in bytes
        mov     bp,2000h ;calculate the amount to add after even scan
        sub     bp,ax   ; lines are drawn to get to the address of
                        ; the next scan line
        mov     dx,1fb0h ;calculate the amount to subtract after odd
        add     dx,ax   ; scan lines are drawn to get to the address
                        ; of the next scan line
        mov     si,ax   ;save width in SI for this erase driver
        mov     al,ah   ;zero AL (data to blank with)
        jmp     [bx+erase_height_vector_table-2] ;-2 because there is
                                ; no 0 lines entry point
;
;This is inline code for erasing the image from the screen memory map.
;
elabel  macro   x       ;this macro is used to label the inline code
eline&x&:               ; entry points
        endm
;
x=42                    ;there will be an entry point for each even
                        ; number of lines between 2 and 40. They will
                        ; be labeled "eline2", "eline4", ... "eline40"
        rept    20
x=x-2                   ;calc number of lines for this entry point
        elabel  %x      ;put in label for entry point
        mov     cx,si   ;put width of image in bytes in CX to prepare
        rep     stosb   ; for repeated store string instruction
        add     di,bp   ;calc address of next line DI + (2000h-width)
        mov     cx,si   ;put width of image in bytes in CX to prepare
        rep     stosb   ; for repeated store string instruction
        sub     di,dx   ;calc address of next line DI - (1fb0h+width)
        endm
        ret
;
;This table is used as an indirect address for jumping into
; the inline code for image erasing.
;
erase_height_vector_table label word    ;there is no entry point for
                                ; 0 lines. Starting at 2
                                ; eliminates the need to store
                                ; a dummy entry point address
erase_entry_address     macro   x   ;this macro is used to generate
                dw      eline&x&    ; the labels corresponding to the
                endm                ; inline code entry points
;
x=2
        rept    20
        erase_entry_address     %x
x=x+2
        endm
;
erase_form_driver endp
one     ends
        end
```

LISTING 9: BYTBENCH.ASM

```
;This program benchmarks the byte-move driver.
;Link the byte-move form_driver/erase_form_driver
; module to this program.
;
stack   segment para stack 'STACK'
        db      512 dup(0)
stack   ends
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        extrn   form_driver:near,erase_form_driver:near
```

```
;
iteration_count  dw      0
;
;Lists describing image, location, and motion of 8 objects.
;
;pointers to form byte strings for each object:
form_address     dw  f0, f1, f2, f3, f3, f2, f1, f0
;the index for the last object in these lists:
highest_object_pointer equ (($-form_address)-2)
row              dw 100,100,100,100,100,100,100,100 ;lines (0 - 198)
column           dw  32, 32, 32, 32, 32, 32, 32, 32 ;in bytes (0 - 79)
row_increment    dw  -2,  2,  0, -2,  0,  0, -2,  2 ;lines (0 - 198)
column_increment dw   1,  1,  0, -1,  1, -1,  0, -1 ;in bytes (0 - 79)
left_margin      dw   0,  0,  0,  0,  0,  0,  0,  0 ;byte # (0-79)
right_margin     dw  76, 74, 72, 70, 70, 72, 74, 76 ;byte # (0-79)
top_margin       dw   0,  0,  0,  0,  0,  0,  0,  0 ;line # (0 - 198)
bottom_margin    dw 194,184,174,164,164,174,184,194 ;line # (0 - 198)
;
;Form byte structures, as follows:
;       byte 1: # of scan lines in forms.
;       byte 2: # of bytes per scan line of form.
;       byte 3: first byte of image, followed by rest of bytes forming
;               image, with bytes for top scan line, left to right,
;               first, second scan line next, and so on.
;
f0      db      6,4
        db      0f0h,00fh,0f0h,00fh
        db      0f0h,03fh,0fch,00fh
        db      0ffh,0ffh,0ffh,0ffh
        db      0f0h,0ffh,0ffh,00fh
        db      0f0h,03fh,0fch,00fh
        db      0f0h,00fh,0f0h,00fh
f1      db      16,6
        db      4 dup(6 dup(055h))
        db      4 dup(6 dup(0ffh))
        db      4 dup(6 dup(0aah))
        db      4 dup(6 dup(055h))
f2      db      26,8
        db      26 dup(0ffh,0aah,0aah,055h,055h,0aah,0aah,0ffh)
f3      db      36,10
        db      9 dup(10 dup(0ffh))
        db      3 dup(0ffh,0ffh,6 dup(0aah),0ffh,0ffh)
        db      3 dup(0ffh,0ffh,0aah,4 dup(055h),0aah,0ffh,0ffh)
        db    6 dup(0ffh,0ffh,0aah,055h,000h,000h,055h,0aah,0ffh,0ffh)
        db      3 dup(0ffh,0ffh,0aah,4 dup(055h),0aah,0ffh,0ffh)
        db      3 dup(0ffh,0ffh,6 dup(0aah),0ffh,0ffh)
        db      9 dup(10 dup(0ffh))
;
start   proc    far
        push    ds          ;set up for return to DOS
        sub     ax,ax       ; through the instruction at DS:0 set
        push    ax          ; up by DOS when it loads this program
        cld
        push    cs
        pop     ds          ;DS and CS are to be the same
        mov     ax,0b800h   ;ES is to point to Color Graphics
        mov     es,ax       ; Adapter's memory buffer
        mov     ax,0004h    ;set 320x200 color mode
        int     10h
;
;Set number of times to move all objects
;
        mov     [iteration_count],700   ;times to repeat move loop
;
;For each iteration, move each object in turn by erasing it,
; moving it one increment, and drawing it at the new position.
;
next_iteration:
        mov     si,highest_object_pointer   ;start at last object
;
;Move each object in turn.
;
move_next_object:
;
;Erase the object at its present position.
;
        push    si              ;save object index
        mov     bx,[si+row]     ;get line at which to start erasing
        mov     cx,[si+column]  ;get col. at which to start erasing
;get address of form for object to erase:
        mov     si,[si+form_address]
        call    erase_form_driver ;erase a rectangular area = to the
                                  ; dimensions of the object whose
                                  ; form is pointed to in SI
        pop     si                ;restore the object index
;
;Advance the object's row and column and adjust increments
; so the object remains within its boundaries.
;
;If adding the row increment to the row would place it outside
; its margins...
;
        mov     ax,[si+row]             ;test the new line position
        add     ax,[si+row_increment]   ; to see if it goes outside
        cmp     ax,[si+top_margin]      ; its limit
        jb      negate_row_increment    ;if outside negate the
        cmp     ax,[si+bottom_margin]   ; increment so that it will
        jbe     test_column_increment   ; move towards its other limit
;
;...then make the row increment negative if positive and
; positive if negative.
;
negate_row_increment:
        neg     [si+row_increment]   ;make it move in other direction
;
;If adding the column increment to the column would place it
; outside its margins...
;
test_column_increment:
        mov     ax,[si+column]             ;if the column for the object
        add     ax,[si+column_increment]   ; would go outside its left
        cmp     ax,[si+left_margin]        ; or right limits, then
        jb      negate_column_increment    ; negate its increment so
        cmp     ax,[si+right_margin]       ; that it will move in the
        jbe     add_increments             ; opposite direction
;
;...then make the column increment negative if positive and
; positive if negative.
;
negate_column_increment:
        neg     [si+column_increment]   ;set to move in opp. direction
;
;Add the increments to the row and column to arrive at the
; object's next position.
;
add_increments:
        mov     ax,[si+row_increment]      ;calculate next line postion
        add     [si+row],ax                ; and store it
        mov     ax,[si+column_increment]   ;calculate next col. postion
        add     [si+column],ax             ; and store it
;
;Draw the object at the new location.
;
        push    si                      ;save this object index
        mov     bx,[si+row]             ;find line and column number
        mov     cx,[si+column]          ; at which to place object
        mov     si,[si+form_address]    ;find address of object's form
        call    form_driver             ;put object's image into screen
        pop     si                      ;restore the object index
;
        sub     si,2                    ;point to next object to move
        jns     move_next_object        ; if not done jmp to move it
;
        dec     [iteration_count]       ;count down number of times to
        jnz     next_iteration          ; move all the objects
;
;Reset the mode to 80x25 color text mode.
;
        mov     ax,0003h                ;before returning to DOS,
        int     10h                     ; set screen to 80x25 text mode
;
;Return to DOS.
;
        ret                             ;return though instruction at
                                        ; start of PSP set up by DOS
start   endp
one     ends
        end     start
```

LISTING 10: BYTFRNGE.ASM

```
;This program benchmarks the byte-move driver with automatic
; erasure by a blank fringe.
;Link the byte-move form_driver/erase_form_driver
; module to this program.
;
stack   segment para stack 'STACK'
        db      512 dup(0)
stack   ends
;
one     segment para public 'CODE'
        assume  cs:one,ds:one,es:nothing
        extrn   form_driver:near
;
iteration_count  dw     0    ;will hold # of times to move the objects
;
;Lists describing image, location, and motion of 8 objects.
;
;pointers to form byte strings for each object:
form_address     dw  f0, f1, f2, f3, f3, f2, f1, f0
;the index for the last object in these lists:
highest_object_pointer equ (($-form_address)-2)
row              dw 100,100,100,100,100,100,100,100 ;lines (0 - 198)
column           dw  32, 32, 32, 32, 32, 32, 32, 32 ;bytes (0 - 79)
row_increment    dw  -2,  2,  0, -2,  0,  0, -2,  2 ;lines (0 - 198)
column_increment dw   1,  1,  0, -1,  1, -1,  0, -1 ;bytes (0 - 79)
left_margin      dw   0,  0,  0,  0,  0,  0,  0,  0 ;byte # 0-79)
right_margin     dw  74, 72, 70, 68, 68, 70, 72, 74 ;byte # (0-79)
top_margin       dw   0,  0,  0,  0,  0,  0,  0,  0 ;line # (0 - 198)
bottom_margin    dw 190,180,170,160,160,170,180,190 ;line # (0 - 198)
;
;Form byte structures, as follows:
;       byte 1: # of scan lines in forms.
;       byte 2: # of bytes per scan line of form.
;       byte 3: first byte of image, followed by rest of bytes forming
;               image, with bytes for top scan line, left to right,
;               first, second scan line next, and so on.
f0      db      10,6
        db      2 dup(6 dup(000h))
        db      000h,0f0h,00fh,0f0h,00fh,000h
        db      000h,0f0h,03fh,0fch,00fh,000h
        db      000h,0ffh,0ffh,0ffh,0ffh,000h
        db      000h,0f0h,0ffh,0ffh,00fh,000h
        db      000h,0f0h,03fh,0fch,00fh,000h
        db      000h,0f0h,00fh,0f0h,00fh,000h
        db      2 dup(6 dup(000h))
f1      db      20,8
        db      2 dup(8 dup(000h))
        db      4 dup(000h,6 dup(055h),000h)
        db      4 dup(000h,6 dup(0ffh),000h)
        db      4 dup(000h,6 dup(0aah),000h)
        db      4 dup(000h,6 dup(055h),000h)
        db      2 dup(8 dup(000h))
f2      db      30,10
        db      2 dup(10 dup(000h))
        db  26 dup(000h,0ffh,0aah,0aah,055h,055h,0aah,0aah,0ffh,000h)
        db      2 dup(10 dup(000h))
f3      db      40,12
        db      2 dup(12 dup(000h))
        db      9 dup(000h,10 dup(0ffh),000h)
        db      3 dup(000h,0ffh,0ffh,6 dup(0aah),0ffh,0ffh,000h)
     db  3 dup(000h,0ffh,0ffh,0aah,4 dup(055h),0aah,0ffh,0ffh,000h)
     db  6 dup(000h,0ffh,0ffh,0aah,055h,0,0,055h,0aah,0ffh,0ffh,000h)
     db  3 dup(000h,0ffh,0ffh,0aah,4 dup(055h),0aah,0ffh,0ffh,000h)
     db  3 dup(000h,0ffh,0ffh,6 dup(0aah),0ffh,0ffh,000h)
     db  9 dup(000h,10 dup(0ffh),000h)
     db  2 dup(12 dup(000h))
;
start   proc    far
        push    ds              ;set up for return to DOS
        sub     ax,ax           ; through the instruction at DS:0 set
        push    ax              ; up by DOS when it loads this program
        cld                     ;the form driver counts up
        push    cs
        pop     ds              ;DS and CS are to be the same
        mov     ax,0b800h       ;ES is to point to Color Graphics
        mov     es,ax           ; Adapter's memory buffer
        mov     ax,0004h        ;set 320x200 color mode
        int     10h             ;
;Set number of times to move objects
;
;number of times to repeat move loop:
        mov     [iteration_count],700
;For each iteration, move each object in turn by moving
; it one increment and drawing it at the new position.
;
next_iteration:
        mov     si,highest_object_pointer   ;start at last object
;Move each object in turn.
;
move_next_object:
;
;Advance the object's row and column and adjust increments
; so the object remains within its boundaries.
;If adding the row increment to the row would place it outside
; its margins...
;
        mov     ax,[si+row]             ;test the new line position
        add     ax,[si+row_increment]   ; to see if it goes outside
        cmp     ax,[si+top_margin]      ; its limit
        jb      negate_row_increment    ;if outside negate the
        cmp     ax,[si+bottom_margin]   ; increment so that it will
        jbe     test_column_increment   ; move towards its other limit
;
;...then make the row increment negative if positive and
; positive if negative.
;
negate_row_increment:
        neg     [si+row_increment]      ;make it move in other direction
;
;If adding the column increment to the column would place it
; outside its margins...
;
test_column_increment:
        mov     ax,[si+column]            ;if the column for the object
        add     ax,[si+column_increment]  ; would go outside its left
        cmp     ax,[si+left_margin]       ; or right limits, then
        jb      negate_column_increment   ; negate its increment so
        cmp     ax,[si+right_margin]      ; that it will move in the
        jbe     add_increments            ; opposite direction
;
;...then make the column increment negative if positive and
; positive if negative.
;
negate_column_increment:
        neg     [si+column_increment]   ;set to move in opp. direction
;
;Add the increments to the row and column to arrive at the
; object's next position.
;
add_increments:
        mov     ax,[si+row_increment]     ;calc the next line postion
        add     [si+row],ax               ; and store it
        mov     ax,[si+column_increment]  ;calc the next column postion
        add     [si+column],ax            ; and store it
;
;Draw the object at the new location.
        push    si                      ;save this object index
        mov     bx,[si+row]             ;find line and column # at
        mov     cx,[si+column]          ; which to place the object
        mov     si,[si+form_address]    ;find the addr. of object's form
        call    form_driver             ;put object's image into screen
        pop     si                      ;restore the object index
;
        sub     si,2                    ;point to next object to move
        jns     move_next_object        ; if not done jmp to move it
;
        dec     [iteration_count]       ;count down number of times to
        jnz     next_iteration          ; move all the objects
;
;Reset the mode to 80x25 color text mode.
        mov     ax,0003h                ;before returning to DOS,
        int     10h                     ; set screen to 80x25 text mode
;
;Return to DOS.
        ret                             ;return though instruction at
                                        ; start of PSP set up by DOS
start   endp
one     ends
        end     start
```

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Diary of an

I traded my 16K machine and all those disks for Lotus® 1-2-3 and 256K. And immediately got the urge to merge. I started by merging regional statements in Maine. But before I could get to Iowa, I ran out of gas.

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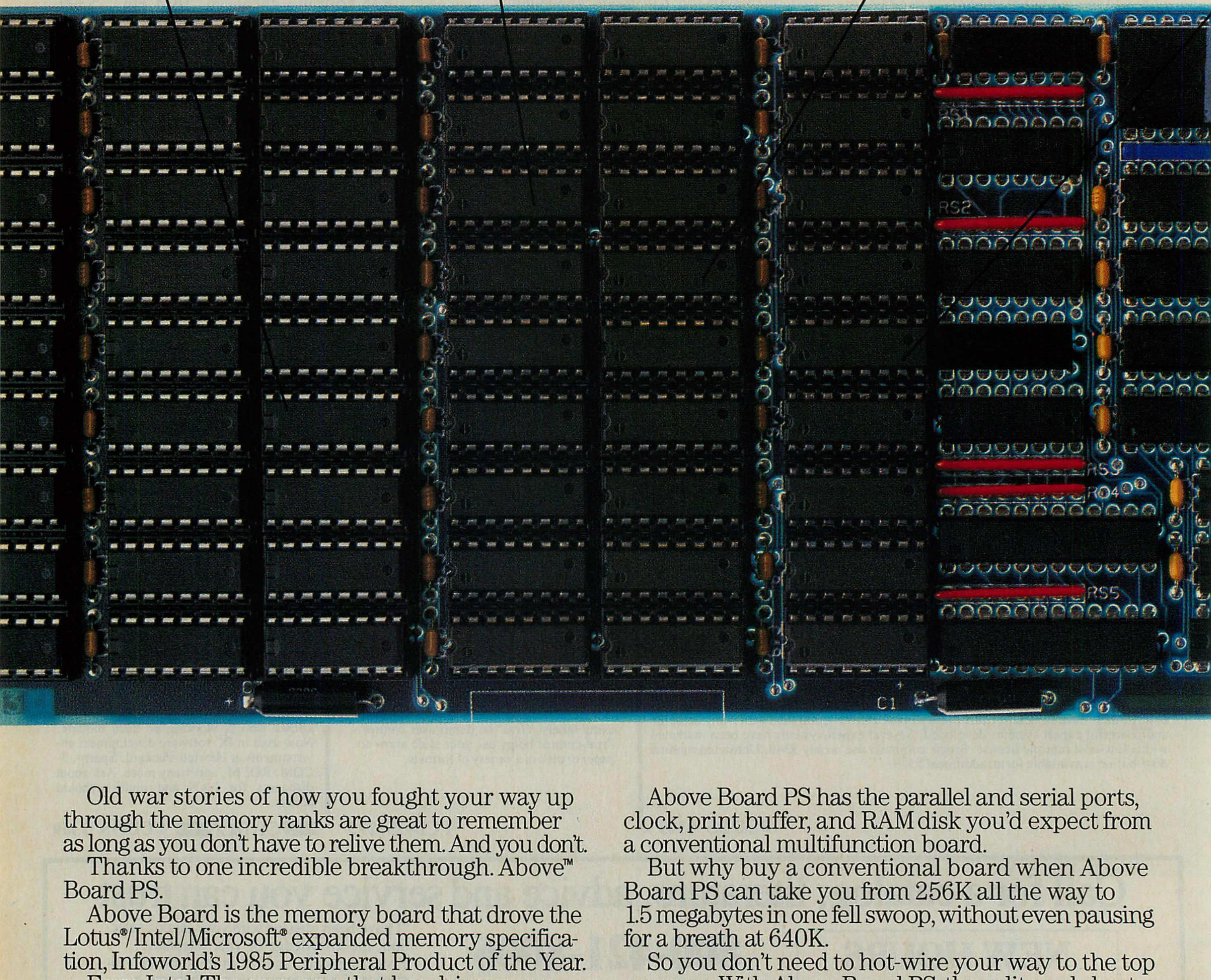

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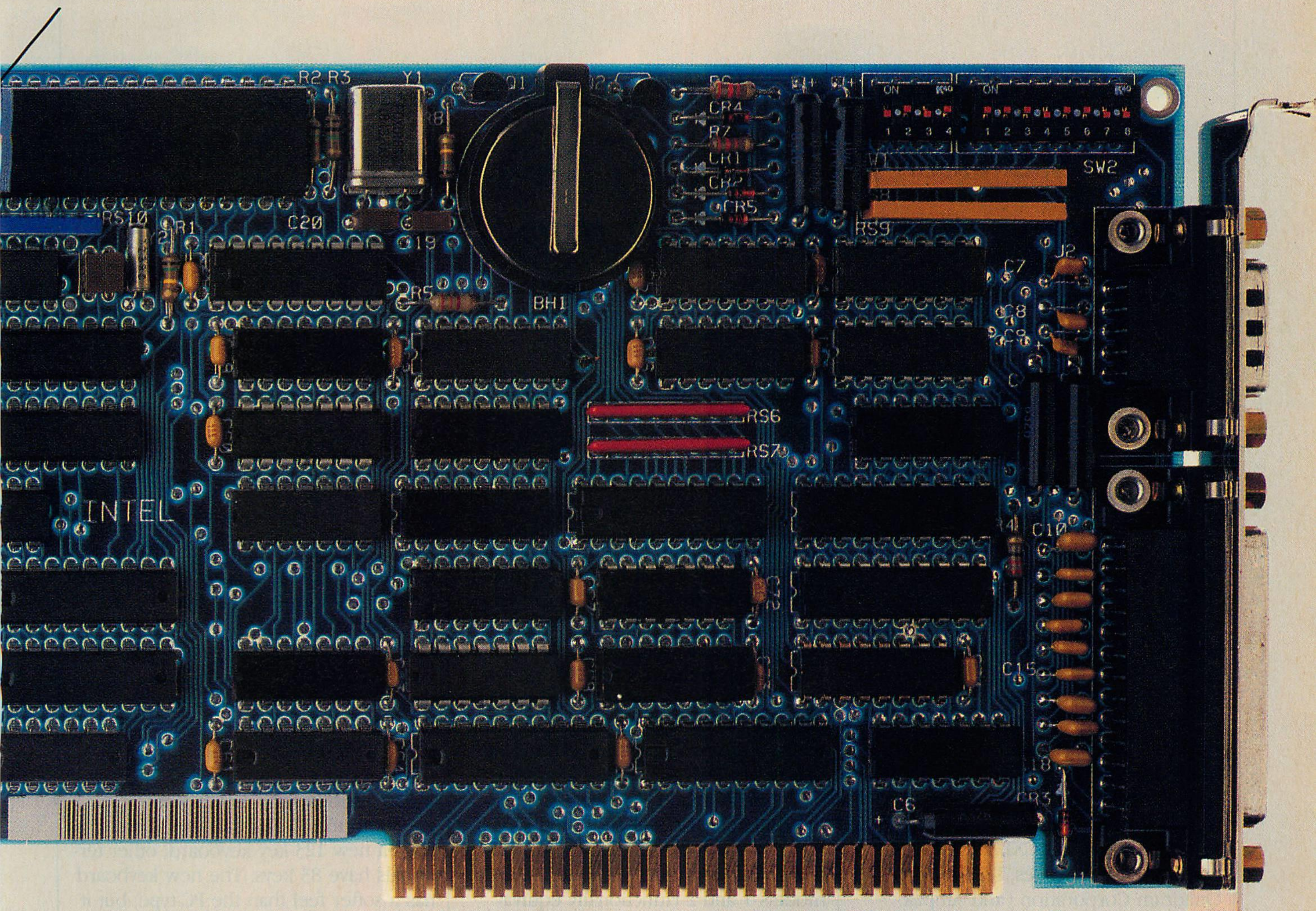

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The 5251 Connection

Several good choices are available to the user planning to integrate IBM 5251 display station emulation into a PC-based system.

GERRY KAPLAN

The original IBM 5251 display station boasts a long-term relationship with System/3x computers. Although IBM has introduced more powerful models to the System/3x line and many new terminals, the 5251 continues to set the standard. Now the PC, PC/XT, or PC/AT can deliver all the power of the 5251 terminal with little more difficulty than installing an emulation board and its attendant software.

Twin-axial 5251 emulation products from AST Research, CXI, Digital Communications Associates, IDEAssociates, Quadram Corporation (and Ampak Business Systems), and Techland Systems are reviewed here. Table 1 provides a comparison of features among the products. (Remote 5251 emulation products are used much less frequently and are not reviewed here. Also note that while the System/36 is used as the principal focus, all System/3x workstations are similar in concept.)

The 5251 terminal does not appear to function the way the regular ASCII terminal does. The most notable difference is speed: screen updates do not "slide" down from the top of the display, they appear all at once. More attribute combinations are available on a 5251 terminal than on the PC's monochrome display, as are a few innovative capabilities, such as column separators, which appear as very thin vertical lines that fit between each set of character positions in a field. The keyboard has the IBM Selectric feel and layout.

IBM extended the family of 5251-compatible terminals with the 5291, models 1 and 2 (functionally equivalent), and the 3180-2, with advanced features. The 5292, models 1 and 2, and the 3179-2 are similar to the 5291 and 3180, but with color; the 5292-2 provides bit-mapped color graphics.

The 5291/2 models have been ergonomically redesigned, with more tilt options and a display resembling the PC's. These terminals differ from the 5251 in that they have a PC-type keyboard instead of the Selectric-type. The 3180-2 workstation, like the 5291, is ergonomically designed, and it is the only 5250-family terminal that can display 132 characters per line instead of 80. The 3179-2 color display station is similar in operation to the 3180-2, except that it cannot display 132 character lines; it can, however, display text in seven high-resolution colors. The color displays support blinking and underlining as attributes for most colors.

Both the 3179-2 and the 3180-2 have a new 123-key keyboard; other terminals have 83 keys. The new keyboard has a softer feel than the PC-type, but it retains a tactile feedback. In addition, the 3179/80 models offer features not found on the other terminals, including keystroke save/play and the ability to set terminal settings from the keyboard.

THE RIGHT CONNECTIONS

Most small systems use ASCII terminals connected through an RS-232 port on the computer or on a modem (see figure 1). Each cable accommodates one

ILLUSTRATION • ANDY LEVINE

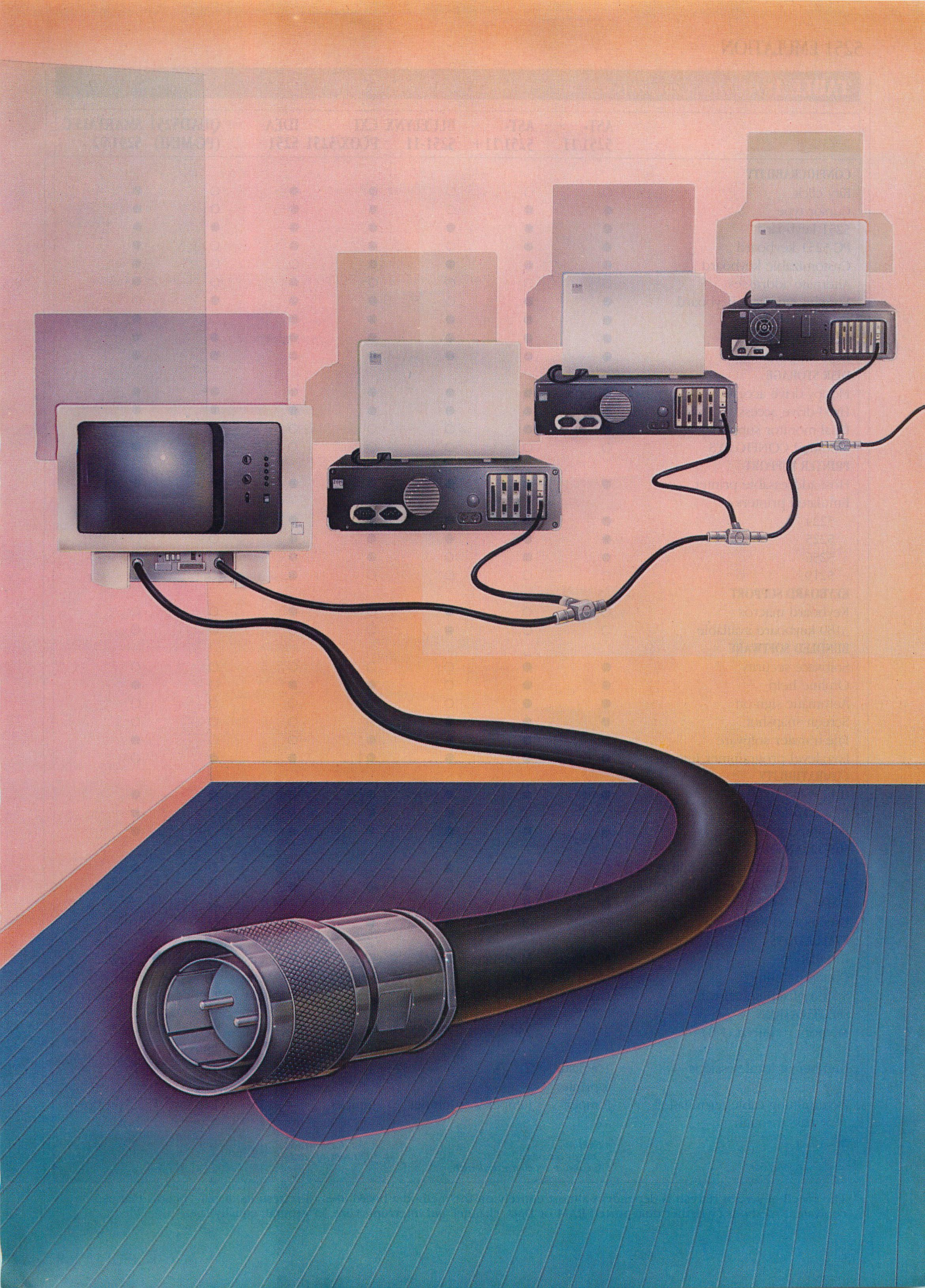


TABLE 1: *Features Comparison*

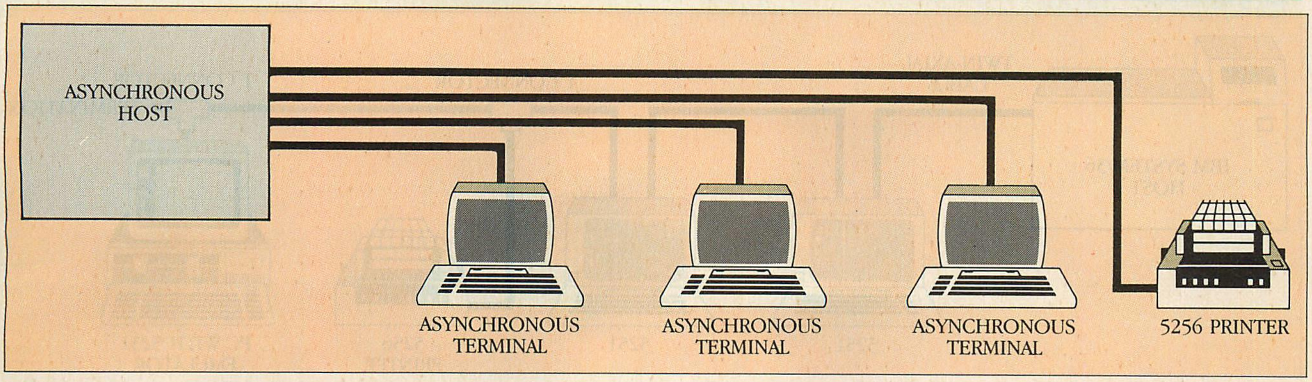
	AST-5251/11	AST-5251/11+	BLUELYNX 5251-11	CXI PCOX/5251	IDEA 5251	QUAD5251 (PC-MINI)	SMARTALEC 5291/92
CONFIGURABILITY							
Key click	○	○	○	●	●	○	●
Cursor type	●	●	○	●	●	○	●
5251 keyboard	●	●	●	●	●	●	●
PC-5251 keyboard	●	●	○	●	●	○	●
Customizable keyboard	●	●	●	●	○	○	●
Alternate addresses	○	○	○	○	●	○	● [a]
Foreign language keyboard	●	●	○	●	●	●	○
Custom printer	●	●	●	●	●	○	●
CGA support	●	●	●	●	●	●	●
EGA support	●	●	●	●	●	●	●
DISK STORAGE							
Floppy-drive access	●	●	●	●	●	● [b]	●
Hard-drive access	●	●	●	●	●	● [b]	●
Dual-monitor support	●	●	○	○	○	○	○
Modified CONFIG.SYS	○	○	○	○	○	○	●
PRINTER SUPPORT							
Host-addressable printer	●	●	●	●	●	○	●
Emulated printers							
5224	●	●	●	●	●	○	○
5225	●	●	●	●	●	○	○
5256	●	●	○	●	●	○	●
5219	○	○	○	○	●	○	○
KEYBOARD SUPPORT							
Keyboard macros	○	○	● [c]	○	●	○	○
3180 keyboard available	○	○	●	○	○	○	○
BUNDLED SOFTWARE							
Software security	●	●	○	○	○	○	○
On-line help	●	●	○	●	●	○	●
Automatic sign-on	●	●	○	○	○	○	○
Screen snapshot	●	●	●	○	○	○	○
File-transfer software	●	●	●	●	○	○	●
Low-level programmer interface	●	●	●	● [d]	●	●	○
COMBATIBILITY							
IBM FSU	●	●	●	●	●	●	●
IBM transfer facility	○	○	●	●	●	○	●
PC support	●	●	●	●	●	○	●
MISCELLANEOUS							
Session maintained through reset	○	○	●	○	○	○	●
Full 5251 display attributes option	●	●	○	○	●	○	○
DMA	●	●	○	○	○	●	○
Dual-ported RAM	○	○	●	●	●	○	○
EVALUATIONS							
Installation	Moderate	Moderate	Easy	Easy	Very easy	Moderate	Very easy
Configurability	Moderate	Moderate	Very easy	Very easy	Very easy	Very easy	Very easy
Speed of screen refresh	Fast	Fast	Very fast	Very fast	Very fast	Fast	Moderate
SPECIFICATIONS							
Memory required (KB)	256	256	23	36	36	16 mono./ 28 color	192
Number of local sessions	1 wrksn. 4 printer	7	4	4	4	1	7
Determining cable termination or pass-through	Jumper	Jumper	Jumper	Jumper	— [e]	Dip	On splice box

● = *Good*
○ = *Bad*
— = *Not applicable*

[a] *Bidding*
[b] *One or the other*
[c] *Maximum six-character length*
[d] *Not documented*
[e] *On rear of card*

The speed of screen refresh is dependent almost entirely on the method a board uses to refresh its display; boards that use equivalent methods (whether dual-ported RAM or DMA channel and interrupts) are, in general, equally fast.

FIGURE 1: *Asynchronous Terminal/host Connection Scheme*



Each connected device (whether a terminal or a printer) requires its own communication link (through dedicated cable or modem) to the host. The cost of each link must be justified by the use of its connected device alone.

terminal: a system with 12 terminals would have 12 cables running from the CPU. The System/36 uses twin-axial cable, which is similar to the coaxial cable used for cable television except that the twin-axial cable has two center conductors (hence the "twin").

Depending on the model, a System/36 has one or more twin-axial ports. Each port can address as many as seven workstations, each with its own address (0 through 6). (Each terminal has switches that determine the logical address to which it responds.) To attach several displays to the host, a cable is run from the CPU to the first terminal, another cable is run from that terminal to the next, and so on (see figure 2.) The maximum distance a terminal can be located from the host is 5,000 feet.

The 5251-12 workstation (for distances of more than 5,000 feet) connects to a modem rather than to the host and acts as a communications controller for as many as seven twin-axial devices through four separate twin-axial ports (see figure 3). An alternative approach is to use the 5294 remote control unit, which is similar to the 5251-12, but without any terminal facilities of its own—it is simply a workstation controller with a bisynchronous port for connection to a bisynchronous modem. The 5294 supports either four (model CF1) or eight (model CF2) additional terminals. One important difference exists between the 5294 and the 5251-12 workstations: the controller microcode within the 5294 is programmable; the 5251-12 microcode is in ROM. Some System/36 applications programs, including Displaywrite/36, that modify this microcode to provide additional display attributes and screen formatting options *cannot* be run from a 5251-12.

Most ASCII terminals operate in full-duplex character mode: when a key is pressed, its ASCII value is immediately sent to the host; the host processes the key and echoes the character back to the display. The CPU must do all the "dirty" work such as validity testing or checking for the Enter key.

The System/36 uses a different approach. A specialized processor, the *workstation controller*, handles all I/O with its terminals. Visually, the System/36 terminals appear to be functioning in half-duplex block mode. This, however, is not the case. Terminal functions that reside entirely within smart terminals, such as the 3278, are divided here between the workstation controller and the relatively dumb 525x terminal. All terminal functions are managed directly by the workstation controller.

A typical interactive application observes the following sequence when it requires input from the user. First a screen format or *panel* is displayed containing all text descriptions or prompts the user will need in order to know what to enter. Special nondisplayable markers called *attributes* are included in the format that tell the controller where each input or output field is located and what type of data is to be put in that field.

When the panel is completely displayed, the user types the data into the fields; only when all the fields have been filled in should Enter be pressed. For most block-mode terminals, the logic for this functionality is located within the terminal's ROM. On the System/36 however, this logic is in microcode that is loaded into the workstation controller's memory at IPL. Thus the terminal appears to be checking the user's input while it is being typed.

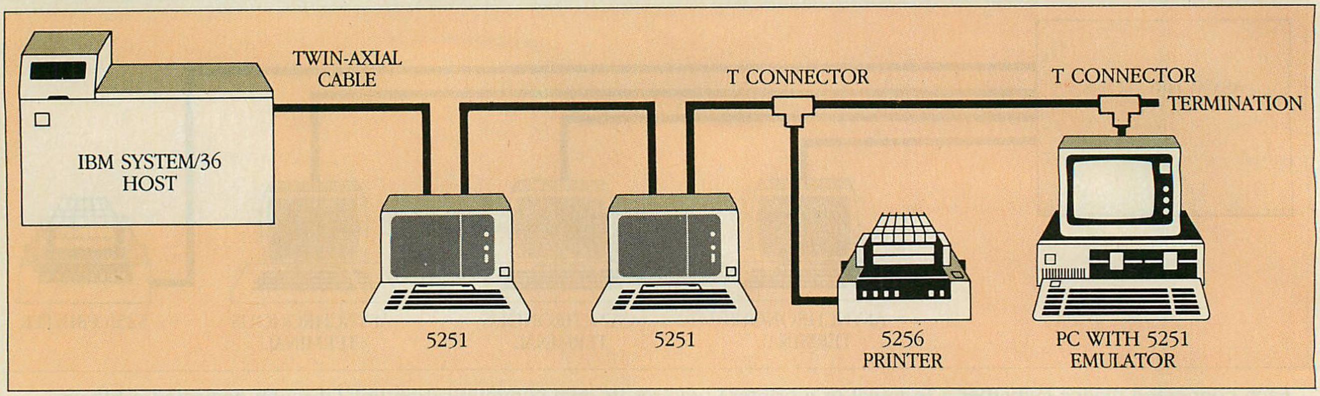
To illustrate, consider a user who begins to type alpha data into a field that is designated for numeric characters only. The instant a non-numeric key is pressed, the terminal will freeze up and indicate that the field requires numeric input. The operator must press the Error Reset key to continue. This error checking is performed by the workstation controller, not the terminal or the main CPU. So while it appears that the terminal is sending blocks of data to the System/36 at isolated intervals, in fact, the workstation controller and the terminal are in nearly continuous two-way commmunications while the user is typing in data. The communications protocol is IBM proprietary.

Further, because the controller handles all terminal I/O, the main system processor (MSP) is free to concentrate on other CPU-dependent functions. It is only when Enter or a command key (discussed below) is pressed that the information in the input fields is returned to the user program.

The keyboards on System/36 terminals have 24 command keys, which are analogous to the PC's function keys. On 3179/80 terminals, all 24 are mapped onto separate keys on the keyboard, similar to the double row of program function (PF) keys on the 3278. On earlier-model terminals, the command keys are mapped onto key combinations like the Ctrl and Alt combinations on the PC. Other keys have specific labeled functions: Roll Up, Roll Down, Print, Help, and Dup. An application can indicate to the workstation controller which of these keys are valid at a given time. If the operator presses an invalid key, the terminal will freeze and display a message to that effect. Error Reset must be pressed to continue.

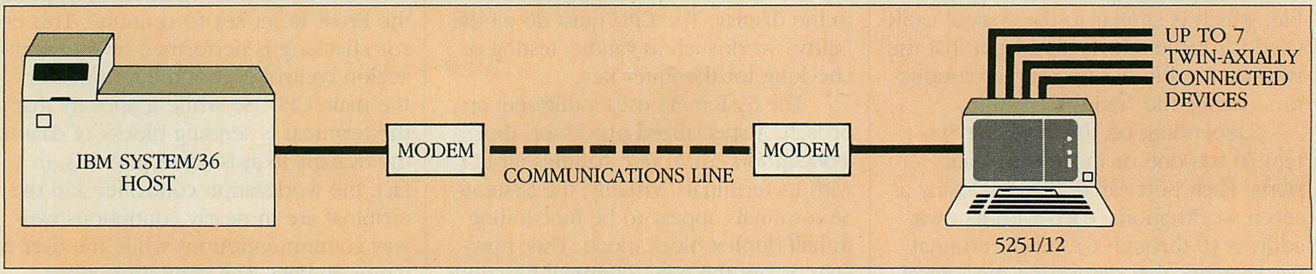
All 5250-family terminals have *edge indicators*—originally, five lamps on the right side of the CRT screen. They indicate the state of toggle conditions in a manner analogous to the CapsLock and NumLock lamps on an AT keyboard for

FIGURE 2: *System/36 Twin-axial Connection Scheme*



Early IBM terminals have two ports for "pass through" connection to other terminals. More recent terminals and most emulation boards have only one port and use special T-connectors to pass through or terminate the cable as required.

FIGURE 3: *5251/12 Cluster Connection Scheme*



A 5251 model 12 can act as a remote workstation controller and support a total of seven twin-axial devices attached to it. Remote operation over a non-twin-axial line is required when more than 5,000 feet separate host and terminals.

System Available, Input Inhibited, Message Waiting, Keyboard Shift, and Insert Mode. In later terminal models, the lamps were replaced by small character blocks appearing on the screen itself, appearing and disappearing according to the state of their respective toggles.

POP AND PERFORMANCE TESTING

All of the products reviewed are twin-axial 5251 display station emulators. Testing the speed of these boards is difficult. However, because the transfer rate between 52xx terminals and the host is approximately one megabaud, normal screen refreshes should be very fast. This is difficult to judge by sight, so a program called POP, that uses the 5251's capabilities heavily, was run.

When POP (for Programmer and Operator Productivity Aid) was initiated, it first was requested to display all members in the current library. This results in a full-screen formatted directory of the library. Next to each library member name is a field for a special command. (A library member is a source or object code file.) Producing a screen format is *not* a simple matter of displaying 2,000 characters of text; rather, it is a complex dialog between the workstation controller and the terminal itself. Because so many fields and so much text are printed, the terminal must receive a large amount of commands and text from the workstation controller. Remembering that the commands and text are being transmitted at one megabaud, this is a good way to test the PC's ability to keep up with so much work. A regular 5251 terminal would have no problems accepting such a load, and the text/fields usually would glide down from the top of the screen in about one second as the panel is constructed.

Testing a terminal's speed capabilities without the attributes was done by browsing through a library member, in this case, a COBOL source member. An initial impression in browsing through a member on a 5251 is that the terminal is memory mapped. No cursor movement takes place, and the screen appears to "punch" into view each time the Roll key is pressed. Not all of these emulation boards can handle the POP library directory and member browsing tests as quickly as a true 5251.

IDEA 5251 Emulator. This IDEAcomm 5251 local 5250 emulation package from IDEAssociates includes a twin-axial interface board, twin-axial cable and connectors, a diskette containing emulation software, and a typeset manual.

Hardware configuration and installation of the IDEAcomm board is quite easy. One particularly nice feature is its handling of cable termination: a switch on the board bracket determines whether additional workstations are attached to the cable. Both the I/O address used by the card and the memory address for video storage are set by switches. The default I/O address is 368H, but it may be set to any in the range 0300H to 03FFH. The screen buffers are ordinarily stored at E000H, but may be relocated to any 400H block boundary in the range C000H to E000H, that is, C000H, C400H, C800H, etc. The manual provides textual and graphic explanations of installation.

Configuration is menu driven and flexible. Options include key click on/off, cursor type, and keyboard layout. Up to four local sessions are available and each session can be assigned an alternate workstation address in case the desired one is not available. The emulation software requires no changes to CONFIG.SYS; instead, it loads as a resident DOS extension. Upon invocation,

the software prompts for the desired System/36 address for each of the sessions, and, in about five seconds, confirmation (or denial) is received. If a workstation address is not granted, connection to another address is attempted. Two different keyboard mappings are available: the standard 5251 layout and a modified PC/5250 layout that makes better use of the PC's special keys.

The IDEAcomm system allows one of the four sessions to be a host-addressable printer, and several printer configurations are included with the software, along with a utility to produced a customized version. Emulated printers include the 5224, 5225, 5256, and 5219. The emulator's printer driver allows for System/36 background printing on the attached PC printer. When configured as an IBM 5224 or 5225, the PC printer supports their compressed printing and graphics capabilities.

Each session is an LU (logical unit.) Switching among the LUs is accomplished with a special command key. When a printer session is requested, a special menu is displayed giving the status of the attached printer. This menu offers the indicators and switches of the emulated printer, such as System Available, Ready, Error Check, and LPI (lines per inch) and CPI (characters per inch) indicators. This screen also allows the operator to suspend host printing so that the PC may reclaim the printer for its own output. Options are available to send a form feed, a line feed, or a Reset command to the attached printer.

Configuring the printer also can be accomplished through the software. A special screen allows the specification of command strings for special 52xx printer functions. The IDEA manual includes a table of the string specifications for several popular printers.

One complete section of the appendix is devoted to the technical details of the emulation system. Although it is aimed at advanced users, it shows how to write specialized software that can bypass the IDEA emulation package and control the emulation hardware and microcode directly. Memory maps are included, as is a thorough description of how to enable/disable the hot key—note that the hot key definition (Alt-L) cannot be changed. The software also supports keyboard macros.

For screen updates, very little difference is apparent between the IDEA emulation and a 5291 terminal. The IDEA board handled the POP directory and browse tests without incident.

The edge indicators on this product have been made more understandable than the normal 5291 status blocks. Rather than having the common II (Input Inhibited) block on the status line, IDEAcomm uses the plain English words *No Input* instead. Perhaps the only annoying feature of this product was its emulation of the 5251's column separator. When the host requests column separators, the IDEA software represents this with the PC's character 254 (a small block). This can become distracting on screens containing many fields and using column separators.

For users who require exact duplication of the 5251's display attributes, IDEAssociates makes the IDEAcomm 5251 D Monitor Adapter, which emulates all 32 of the 5251 display attributes. This adapter replaces IBM's Monochrome Display Adapter, including the printer port, and emulates it totally when the emulator software is not in control. When that software is active, 5251 session screen displays are identical to those of the 525x terminal family. This is a clever idea and a convenience for users who will not settle for something "almost like" the 5251.

The IDEAcomm software is fast. For screen updates, very little difference is apparent between this emulation and a 5291 terminal.

The IDEA emulation software is compatible with many IBM file-transfer products, including IBM FSU on the System/34/36/38, IBM Transfer Facility on the System/3638, and PC support for System/36/38. The IDEAcomm package does not use DMA channel resources; therefore, it will not conflict with hard disks or other hardware that uses that facility. In spite of this, the IDEAcomm system is extremely fast, due mainly to its use of dual-ported RAM on the emulation board (this method is also used by CXI and Techland).

The IDEAcomm emulation package and Techland's BlueLynx were the only packages that included detailed information in their manuals for problem determination. This is complemented by IDEA with a special section containing descriptions of all error messages.

CXI PCOX/5251 TWINAX Emulator. The CXI system includes a twin-axial interface board, a cable assembly that supports cable through via a twin-axial T-connector, a diskette containing emulation software, documentation, and file-transfer software. PCOX/5251 can emulate a 5251, models 1 and 11, the 5291, models 1 and 2, and the 5292-1 with an attached 5224, 5225, or 5256 printer. In addition to the standard functions of the 5251/5291/5292, this emulator provides features not available on real 52xx devices. It can support up to four LU devices—four simultaneous host sessions or three host sessions and one printer session. A hot key switches the user from one LU to another.

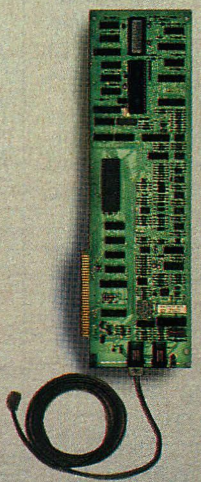
Installation of the PCOX/5251 is simple. Even so, the user must decide if the factory settings for the screen memory address and I/O port addresses will cause conflicts with existing hardware. The default factory settings were used in this review and no hardware problems arose. The default I/O address is 368H, and, like the IDEA board, this may be reconfigured to any address in the range 300H to 3FFH. The screen buffer address defaults to D000H, and may be set to any 800H block in the range C000H to F800H. Cable termination is accomplished at the board level with a special jumper. Alternatively, an external cable terminator (not included with the package) may be used to accomplish termination. The PCOX/5251 does not use a DMA channel or dedicated interrupt vectors, therefore it will not conflict with hard- or floppy-disk drives. Once the card is installed and connected to the host, the remainder of the customization is achieved through configuration software.

The program allows for the selection of device types and addresses, as well as a variety of customizing options. Key click, in addition to keyboard layout and screen handling, can be customized via an options menu. Foreign language keyboards are supported: English/U.S., English/U.K., Austrian-German, French, Italian, Norwegian, Spanish, Swedish, and French-Canadian.

The CXI emulation software is not configured for any specific printer type. Special command strings can be defined during configuration that tell the emulation software what to send the specified printer when certain 52xx printer commands are received. Both CPI and LPI printer settings are defined in this manner. Color attributes also can be modified in the event that a non-IBM color monitor is used. EBCDIC/ASCII and color translation tables are modifiable for both the display and printer.

A unique feature of this board is its ability to intercept the System/3x Print

Adding 5251 communications to your PC is simply a matter of choice:



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key and reroute print output to either the local PC printer or a disk file, instead of the System/3x printer device. This enables the user to press System/36 Print (which in the PCOX/5251 system is mapped onto the PC's F5 key) and have the screen image recorded to the PC printer or to a PC disk file.

The CXI emulation software is similar to that of the IDEAssociates package. The CXI board response to the host is extremely quick, and it handled the POP directory test and POP browse test with no problems. During emulation, the 52xx edge indicator blocks are replaced by words: instead of SA, like many other emulators, the CXI software prints the word System.

The PCOX/5251 emulation system includes CXI's file-transfer software (PCOX/5251 File Transfer) and allows the user to extract data from System/36 databases, copy library members to and from the System/36 and PC, and store PC-originated data in System/36 files for normal processing. It also allows the PC to retrieve print files from the System/36 for printing directly at the PC. CXI also claims its product is compatible with IBM's FSU and Transfer Facility.

The CXI technical staff appears to be very familiar with the product and its operation. The company maintains a toll-free information line.

Smart Alec. This emulation package from Digital Communications Associates (DCA) was by far the easiest of the packages to install and use. Smart Alec can emulate the 5251, 5291, and 5292 color display stations, as well as the 5256 printer. The package includes the emulator board, the 5291/92 emulation software, bidirectional file-transfer software for both the PC and the host computer, and a specially designed splice box that handles the twin-axial connection. The splice box is connected to the emulator board by a short length of cable, and has two twin-axial connectors. A switch located on the box determines whether the connected PC terminates the cable or if additional workstations are present down the line.

Another important feature: this emulator does not require a dedicated DMA channel or interrupt; thus, it will not conflict with LAN hardware, hard disks, or any device requiring either of these. On many of the other boards, the user must first choose the DMA channel (hopefully one that is not in use) and the appropriate interrupt level for the board (5 or 6 depending on PC or PC/XT). The board communicates with the emulation software through eight consecutive I/O addresses in the range 228H to 22FH. No alteration of these addresses is permitted without modification of source code. (The source code is provided; however, its modification is not a simple matter.)

As many as seven sessions can be emulated, with two printer sessions, and, on color monitors, Smart Alec supports two or seven user-selectable colors. The emulator also provides System/36 edge indicators displaying the status of the host, keyboard, and display. The user can choose to have the keyboard remapped in the usual 5291/92 layout or to a more familiar PC layout. No foreign language mappings are provided. As with all of the emulator boards, Smart Alec switches between DOS and emulation via a predefined hot key. DCA includes file-transfer software for transferring files between the emulator PC and the System/34/36.

Smart Alec offers an innovative feature called *address bidding*: several PCs, each with Smart Alec installed, can share a common System/3x workstation address. Under this feature, it is not necessary for each PC to have a dedicated workstation address as with normal terminals. This system thus allows access to the host for more than seven terminals. When any given PC requests an address, it first checks to see if another terminal sharing the address is already in use. If so, the requestor is not granted the address; it then can manually request a valid address.

The CXI board can intercept the System/3x Print key and reroute output to a local printer or disk file instead of the host printer.

For example, consider seven PCs that require intermittent access to the host. Each PC can be set up to use address 3, rather than each requiring sole use of one of the System/36's seven terminal addresses. While one PC is accessing the host, the remaining six are denied access until the active terminal exits emulation.

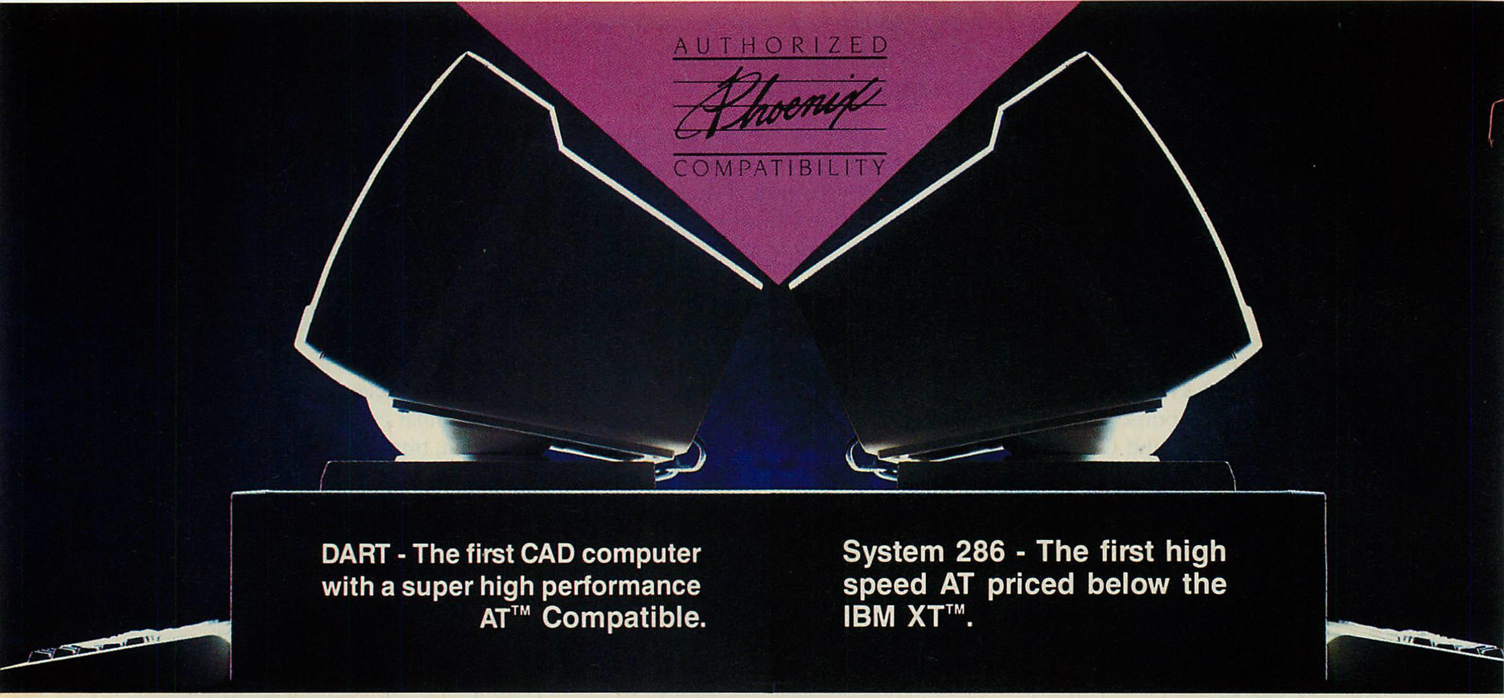
Smart Alec uses custom silicon chips designed especially for its application, thereby reducing the board's chip population. At the heart of the Smart Alec is a customized 8X305 CPU, a high-speed, on-board processor that manages the System/3x protocol independently of the PC's processor. The 8X305 can maintain screen buffers for seven host sessions concurrently. This enables the PC to manage all sessions as well as full stand-alone processing activities simultaneously; as a result, the emulator is not required to be resident in PC RAM at all times to maintain host connection.

This package lets the user set up the terminal emulator so that it can be resident, transient, or automatically loaded at boot time. This gives the product a great advantage over cards that rely on the PC's hardware for processing power. If the PC becomes hung and must be warm booted, the Smart Alec hardware is not affected. It remains functional, and all sessions with the host are maintained. As soon as the emulation software is reloaded into RAM, emulation can continue as if nothing had happened. This is especially helpful when the PC being used for emulation is also used for development of PC applications that are prone to hanging the system.

Although its hardware documentation is not very detailed, the Smart Alec was the easiest installation to perform. One outstanding feature of this board is that the circuit card has no switches: all configuration is accomplished at the software level. Because the card has no jumpers or switches, it simply plugs into any unused full-length slot in the PC. The documentation does include details on cable connection.

Once installed, a menu-driven program takes the user through the configuration of any of the seven devices that are to be emulated. The Smart Alec can be configured to be simply a System/36 printer and not a workstation at all. At this point in configuration, the type of connection is determined. Smart Alec provides the option of having a session connected automatically or manually. If automatic connection is specified, the requested address becomes dedicated to that workstation, and, as soon as emulation is entered, the workstation is connected to the host and available. Using manual connection, the user must request to be connected to the host at the predefined address. If that address is already in use, no connection is made (see the earlier discussion on address bidding).

When emulation is started for the first time, diagnostics are run against the hardware. One notable diagnostic feature on the board is the three LED indicators across the top. These indicators point out the location of any hardware failures that render emulation in-



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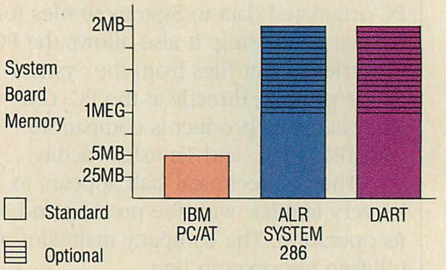

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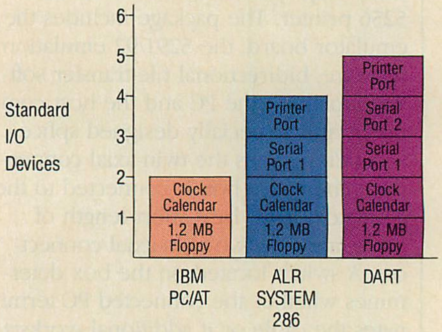

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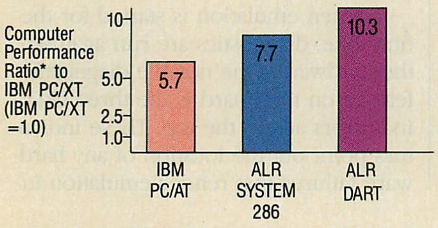

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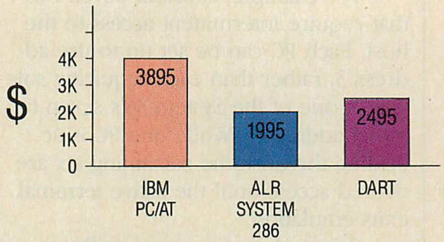

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The concept of having enough memory is misleading. It seems yesterday's 64K of memory was enough. Today, computers require at least 512K in order to run popular programs such as Symphony™ or Framework™. The result? ALR System 286 and DART system both have four times the memory capability built into its 'motherboard' so you don't have to pay for it tomorrow.

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operative: one light indicates whether the host is available, another whether the microcode in the Smart Alec's CPU is functioning, the third indicates errors on the communications lines.

Smart Alec has predefined hot keys for switching among emulated sessions. As noted, up to seven independent sessions can run concurrently on the host. The eighth session is a special information session that provides complete status of activity occurring on the twin-axial line. This session has indicators for communication errors and system availability, and others that show the current status of Smart Alec's CPU. In essence, this eighth display provides the same information that can be obtained from the LEDs on the card.

When the user switches to a printer session, a special screen is displayed that emulates all the switches and indicators on the 5256 printer console. This is the point at which the user can switch between on-line and off-line. Form-feed and line-feed requests also can be issued from this screen.

The Smart Alec emulation software is compatible with Laguna Laboratories' Decision Link bidirectional file-transfer software, the de facto file-transfer standard in the System/36 world. Smart Alec's program supports an unusually wide variety of data formats on the host and PC; among the types of files supported are ASCII text, BASIC sequential, BASIC random, DIF spreadsheet, Lotus 1-2-3 WKS, Lotus Symphony WRK, DOS print image, California Software's Baby/34/36, and binary image. It also supports user identification and log-on password security, read-only and write-only file protection, and downloading of print files from the System/34/36/38 to the PC printer.

Smart Alec's Enhanced File Transfer software, (available as a separate product) provides additional options for security, print spooling to the host, record selection, multiple file chaining, activity logging, and automatic control of processing through a control file. It includes a host data dictionary and a data query language for the PC. Data security is also quite extensive, providing password protection of data down to the record and field level.

The only disappointing feature of Smart Alec is its speed. It was the slowest emulator tested, and during the POP tests it resembled a terminal operating at around 9600 baud. The screens simply have no punch.

In the busy marketplace of 5250 emulators, the Smart Alec is a sound choice. It is packed with useful features, but remains sufficiently hardware-independent to work properly on any PC in the IBM family and many close compatibles. The DCA technical personnel, who can be reached via a toll-free number, were knowledgeable and helpful about the product and its operation.

Quad5251 (PC-Mini). Quadram markets the Quad5251, which is actually the Ampak Business Systems PC-Mini 5251 emulation system. ABS markets PC-Mini under its own label. The two products are identical and are reviewed as one; for simplicity's sake, the product is referred to throughout as the Quad5251.

Quad5251, which allows the PC to emulate an IBM 5251-11 display, comes packaged with a printed circuit board, a twin-axial T-connector, and a disk containing emulation software. It is bundled with IBM 5250 emulation software and documentation in the original packaging. Only one interactive host session is supported, as well as one DOS session. Emulation switches between PC and terminal mode via a hot key. The PC printer is not host addressable, but the PC's PrtSc key is active and anything displayed as a 5250 screen can be printed on the local printer. Keyboard mappings for English/U.S., English/U.K., Spanish, Italian, French, and German are provided. Unlike the Techland product, this package offers no software API (application program interface) in linkable object modules; however, the IBM manual documents the program interface to emulator features through BASIC and assembly language.

DCA's Smart Alec is a sound choice. It is very rich in features and highly hardware-independent, disappointing only in its speed.

This product's emulation software is a modified version of the archetype IBM 5250 emulation software. Originally, the IBM package supported only a diskette-based PC; the software was later modified to support the fixed disk drive, and access to the floppy disk was rendered inoperative.

Because the card uses an interrupt and a DMA channel, switches must be configured on the card to indicate which channels and interrupts to use. The board may use interrupt levels 5 or 6 and DMA channels 2 or 3. The reviewed card was preconfigured for a PC or AT (rather than an XT), so changes were necessary. Also, DMA/interrupt selection is accomplished through dip switches, which require close attention to the instruction manual to ensure correct settings. Terminate/cable through is also set from these switches.

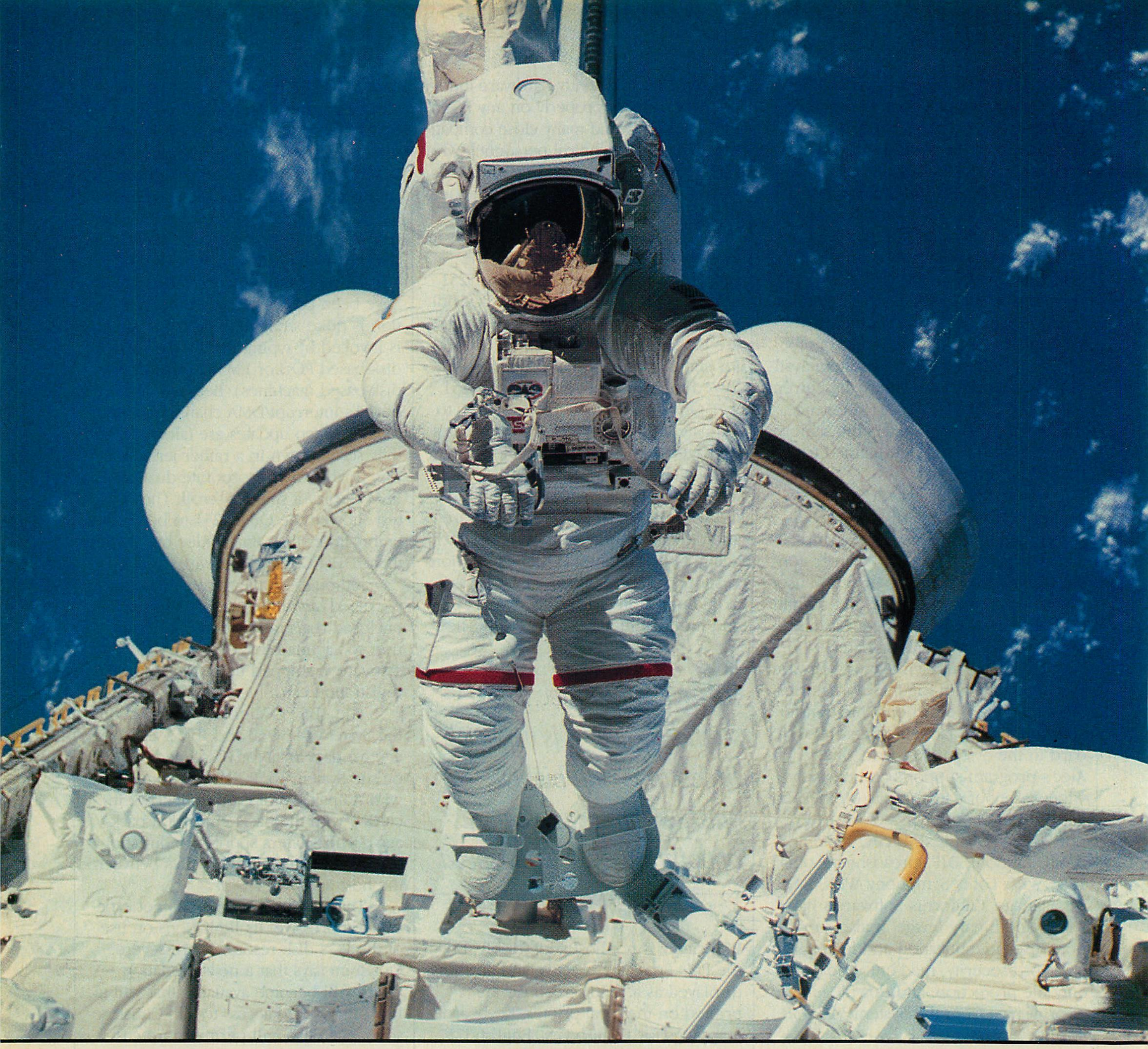
Once all the jumpers and switches have been properly configured, installation is quite straightforward. The system is invoked by typing EMXT (for hard-disk-based PCs) or EM5250 (for floppy-disk-based machines). Because of the board's interrupt/DMA channel configuration, screen updates are fairly fast, but they scroll down in a rather jerky fashion. Boards that incorporate dual-ported RAM display a smooth scroll. The POP test showed the Quad5251 to be considerably faster than Smart Alec but slower than IDEA, CXI, or BlueLynx.

Although no file-transfer software is packaged *with* the Quad5251 board, an enclosed registration card entitles the user to Laguna Labs' Decision Link. The software is shipped upon receipt of the registration card.

The ABS PC-Mini supports FSU on the System/34/36/38 and IBM's EDL (executive data link) for CMAS and MAPICS on the System/36. PC-Mini is compatible with Ampak's Mini-Print utility (not included with the basic emulation package), which offers spooled, bidirectional transfer of printer or data files between the host and PC.

The PC-Mini/Quad5251 is not especially impressive. Its limitations on use of the PC's disk resources are severe. Quadram says that a new emulation board will become available that will allow unhindered access to all PC disk resources. It also will permit more customization, as many as seven sessions, and two host addressable printers. It will emulate the 5251-11, 5291, and a subset of the 3180.

AST-5251/11 and AST-5251/11 Plus. The AST-5251/11 from AST Research is a hardware/software product that enables the PC to emulate a locally attached 5251-11. It supports the 5251 model 11, 5291 models 1 and 2, and the 5292 model 1 color display, as well as the 5256, 5224, and 5225 printers. Two versions are available: the 5251-11 can emulate one display session and four printer sessions; the 5251-11 Plus can emulate any combination of six display sessions and four printer sessions as long as the total sessions do not exceed seven. The extra logic on the 5251 Plus resides on a piggyback board—this was the heaviest and bulkiest product reviewed.



A predefined hot-key combination provides a simple sequence to switch from one emulation session to another; a second hot key switches between DOS and an emulation session. These hot keys cannot be redefined.

Card configuration can be accomplished at the hardware or software level. A configuration program is included to aid in configuring all aspects of the card, from display type to DMA channel selection. All hardware options can be set from software, but certain options can be set only from software.

The AST card is has many features. One unique capability is control of the priority levels for printer operation. In other words, the attached printer may be given a lower priority than one of the emulated sessions (thus increasing the speed of the displays during print operations). A printer table that allows each emulated printer to have its own EBCDIC-to-PC/ASCII translation table is available (and it can be customized).

The keyboard also can be completely remapped—facilitating multilingual support and customized keyboard layouts. Several mappings are provided: Austria-Germany, Belgium, Brazil, Canada, French-Canadian, Denmark-Norway, France, Finland-Sweden, Italy, Portugal, Spain, Spanish-speaking, English/U.K., English/U.S., and English/U.S.-PC. This keyboard also supports both diacritic (which allows the entry of diacritical marks as a means of generating certain non-ASCII foreign characters) and hexadecimal mode.

The AST card lets the user apply password security to the emulation software: the emulation and configuration programs and the hot-key sequences are protected from unauthorized users. File-transfer software is included with the AST package, providing bidirectional data transfer with built-in data conversion. All translation tables (EBCDIC/ASCII and color) are configurable. The emulation software supports the saving of graphics screens when session windows are opened, permitting the emulator's use on graphics applications.

Keyboard macros can be defined to add features not generally found on 5251 terminals. Automatic sign-on macros also can be defined, thus giving configured display sessions the ability to move in sequence through multiple emulation tasks upon start-up. This function is not restricted to sign-on: as many as 250 key scan codes can be sent to the host (to submit batch jobs).

One excellent feature of the AST board is its ability to store "snapshots" of the display screens. In emulation mode, as many as 10 display screens can be saved to PC memory. These snapshots can be recalled at any point during emulation. A screen dump program also is included, which will save all snapshots to a disk file. Also unique to this emulator is its ability to use dual monitors attached to the PC. This allows two sessions to be displayed simultaneously, with switching between them using a hot-key sequence.

Installation of this board is not for the novice. The manual is large and detailed in its description of hardware and software operation. Initially it appeared necessary to change switch settings on the board itself, but a closer study of the manual reveals that anything hardware configurable is also software configurable by a user with a technical background, and the manual provides extensive software configuration details. The DMA channel is preset to 1 and may be configured to 1, 2, or 3. The interrupt level is preset to 2, and may be configured to 2, 3, 4, or 5. Eight consecutive I/O addresses are required. The default range is 250H to 257H; however, this can be reconfigured to use any of the ranges beginning at 250H, 350H, 450H, or 550H.

The AST card enables the user to apply password security to the emulation and configuration programs and the hot-key sequences.

The AST board is fast, although it did not perform as well as other boards (particularly those emulators using dual-ported RAM for screen buffers) with the POP tests. The POP library directory test went well, but browsing through a library member was not as fast as with a true 5251 terminal.

BlueLynx 5251-11. Techland Systems produces this package. Included is a full twin-axial interface board, a diskette with emulation software, and a manual. The most advanced version of the product (III), is reviewed here. The other two versions (I and II) can be upgraded to the advanced levels. Upgrading is accomplished by replacing a ROM on the board, and instructions are included for this procedure.

BlueLynx remaps the PC keyboard to emulate the IBM 5251 keyboard. A hot key switches the user between DOS and System/3x mode. One nice feature is that the hot key is redefinable on the PC and XT; on the AT, the System Request key is used as the hot key and may not be redefined. All three versions support IBM's Virtual Disk File Transfer Utility and Decision Link's 5251-11 file-transfer utility and query program; they are fully compatible with IBM's original 5250 local emulation package. The BlueLynx products include an API that permits access to various functions of the twin-axial board through assembly language programming. These functions are invoked in a fashion similar to regular DOS function calls. All versions also support Techland's ETU (emulator transfer utility). Techland sells an IBM-style 3180 model 2 keyboard as an extra-cost option that functions with all versions of BlueLynx 5251-11.

Version I supports only one LU. Version II supports everything in version I and includes support for two LUs: both can be configured as terminals or one can be configured as a printer. Version II has background print support, allowing host print jobs to continue printing after the user has returned to DOS. In addition, virtual disk support is available for each LU, enabling the user to create virtual DOS disks on the System/36 using facilities of the host FTU.

All features of versions I and II are supported in version III, which supports as many as four LUs. Support is also available for multiple virtual disks, allowing each LU to create its own independent virtual disk. Two PC serial and/or parallel printers can be configured as host-addressable printers. This version also includes routines for support of bar code readers, ticket printers, magnetic stripe devices, light pens, pointing devices, and data gathering/production control devices.

The Techland documentation is clear and precise. Although the emulation card comes with factory settings, the manual describes how to change the switch settings if necessary. Installation is accomplished in minutes. A very thorough diagnostic section is included in the appendix; this section is further divided for ease of use (display problems, printer problems, and so on). The BlueLynx board uses dual-ported RAM rather than a DMA channel, and therefore does not require special settings for use with the hard or floppy disks. This also tends to make the installation procedure less complicated because the user need not be concerned with the details of interrupt or DMA channel assignments. The product requires one

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I/O address, which defaults to 0368H and may be set to any value from 0300H to 03FFH. The dual-ported RAM segment address defaults to D000H, and may be set to any value between C000H and EC00H in muliples of 400H.

Configuration of the emulation software is menu driven and very simple. Many configurations are included that have escape sequences for various printers already defined (HP Laserjet, Toshiba, Epson, etc.). For predefined configurations, the user needs only to define which addresses are desired for each of the LUs.

The emulation system includes a mapping of the PC keyboard to the 5250 keyboard layout; however, the configuration program allows for complete customization of the keyboard. Foreign language keyboards also can be configured in this manner (although none is included with the package). This product emulates the IBM 5224 and 5225 printers (the 5256 printer is also emulated because it uses a subset of the 5224/5 command set). The BlueLynx configuration program includes a special printer customization section, allowing any printer to be set up for 5224 emulation, and thereby enabling the special printing capabilities of Displaywrite/36. Techland's BlueLynx also offers a snapshot feature.

The emulation software resides in only 23KB. However, the emulator hardware and connected sessions can be used in a limited way *without* the emulator software resident and running; this use is available only through the API from a specially written applications program and does not include interactive user sessions. The application must be loaded initially and run.

Sessions with the host are initiated normally. Once sessions are initiated, the PC may be reset using the Ctrl-Alt-Del combination, which removes the emulation software from memory. However, the microcode already has been loaded into the emulator's on-board Z80 processor, which maintains the sessions even through reboot. Any programs that use the API can be loaded and run and can access the host through the sessions initiated while the emulation software was resident.

The BlueLynx 5251 emulator performed well with the POP library directory test. No lag in performance was apparent in its display of the library members. Browsing through a library member also was very fast. According to Techland, its board was produced by the same company that manufactures the IDEAssociates board and the CXI board, both of which also performed well in execution of the POP tests. The key design feature that is shared by all three products is the use of dual-ported RAM for screen buffers.

Techland Systems maintains a toll-free number for technical assistance on the emulation package. The personnel seem very knowledgeable about the product and its operation.

A 5251 CHOICE

In the case of 5251 emulation, more is not always better. Some users might assert the importance of being able to emulate seven different sessions, but many will find three to four sufficient. Being able to access two display sessions is helpful, thereby allowing each session to be editing different files; the user simply switches between them. The primary goal of 5251 emulation is for the PC to reproduce the functions and features of that workstation terminal as closely as possible. The user who has experienced a true 5251 terminal knows the solid feel and fast response as its performance hallmarks.

A most important criterion is the speed at which the screens respond to information transmitted over the twinaxial cable. The POP test usually can identify emulators that do not perform up to standard. If a product appears to emulate a 9600-baud terminal, users should think twice before purchasing it. Screens should respond as if they were memory mapped directly into the CPU's main memory.

The three best boards, the IDEAcomm 5251, the CXI PCOX/5251, and the BlueLynx 5250 are all made by the same company and all use dual-ported RAM instead of DMA channel and interrupts. Each of these boards offers outstanding performance, yet each adds some unique features of its own.

The other products perform acceptably from a speed standpoint, with the exception of DCA's Smart Alec. Yet, although it did not perform as well in these POP tests, Smart Alec probably would perform well on some IBM compatibles that run at clock speeds faster than 4.77 MHz. Moreover, Smart Alec is most likely to work on any IBM compatible in which it is installed, because it is the only board that operates without DMA, interrupts, or dual-ported RAM. Its only contact with the microcomputer is through eight standard 8088 I/O ports. In every aspect other than speed, Smart Alec is superior.

The System/36 is IBM's chosen hub for its departmental computing strategy. Many offices that are new to departmental computing have had PCs for a long time. The 5251 emulation products reviewed here allow users to retain their investment in PC technology while tapping the power of the departmental minicomputer, at minimal cost and disruption of office routines.

AST-5251/11: $895
AST-5251/11 Plus: $995
AST Research
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Irvine, CA 92714
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BlueLynx 5251-11 I, $795; II, $945; III, $1,045
Techland Systems
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CXI PCOX/5251 TWINAX Emulator: $895
CXI, Inc.
3606 W. Bayshore Road
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800/225-PCOX; 415/424-0700
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IDEA 5251 Emulator: $895
5251D Monitor Adapter Card: $495
IDEAssociates
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Quad5251: $995
Quadram Corporation
One Quad Way
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CIRCLE 349 ON READER SERVICE CARD

Smart Alec: $895; file-transfer software, $1,295
Digital Communications Associates
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Gerry Kaplan has been employed by IBM Corporation since he was 16. Now 23, he is a consultant and software developer specializing in the PC line, as well as the System/36.

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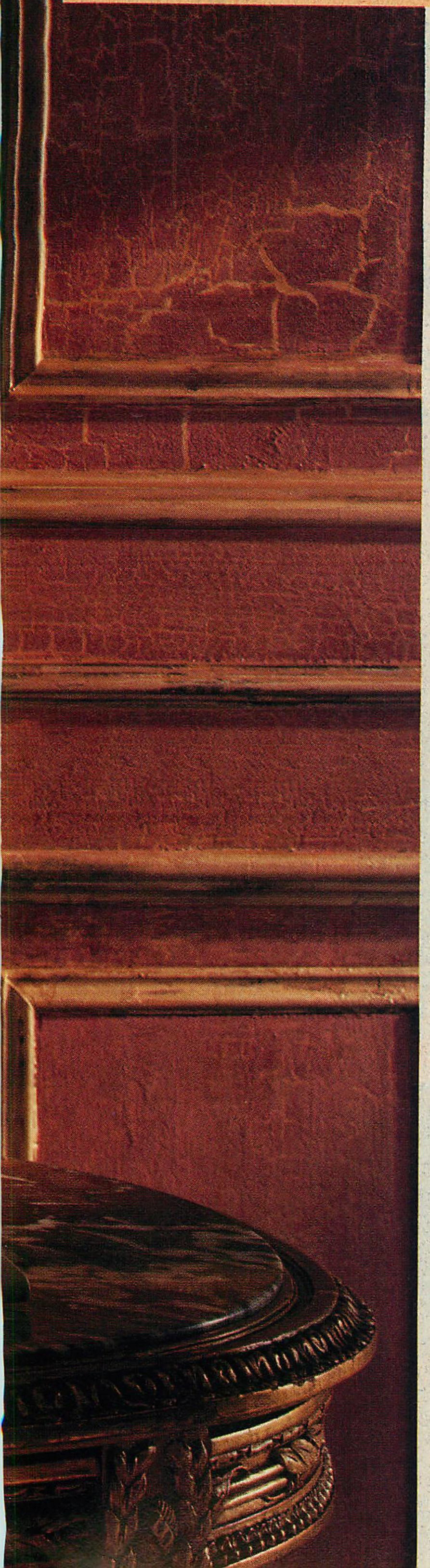

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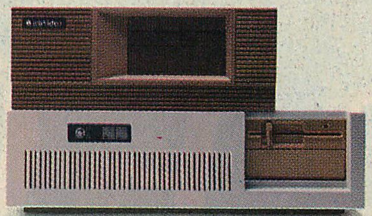

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Approaching the Optimum Pascal

The latest round of Pascal compilers has brought the language close to maturity. With few exceptions, the seven implementations reviewed here live up to Pascal's reputation for facilitating supportable, structured program design.

JEFF DUNTEMANN

As recently as two years ago, Pascal was still an evolving language, just breaking the bonds with its creator, Niklaus Wirth, who had designed the language to teach—and nothing more. A *PC Tech Journal* review of Pascal compilers at that time (see "Pascal Times Four," Jeff Duntemann, July 1984, p. 58) concluded that while the products exhibited many strengths, they had an unfinished feel to them. Two of the products reviewed in 1984—Digital Research's Pascal/MT+86 and Software Building Blocks' SBB Pascal—have fallen into limbo or disappeared entirely. The others—IBM/Microsoft and Turbo Pascal—have been updated and are included for review here. This is a reflection of the winnowing process that has been under way in the industry at large for more than a year.

Today with a few exceptions, Pascal compilers and interpreters are mature, clean, useful products. Seven are reviewed: IBM Pascal, Microsoft Pascal, Mystic Pascal from Mystic Canyon Software, Professional Pascal from Microtec Research, Turbo Pascal from Borland International, UCSD Pascal from Pecan Software Systems, and Utah Pascal from Ellis Computing. IBM and Microsoft Pascal are different releases of the same underlying product and therefore have very similar features.

To be reviewed here, a Pascal compiler must meet these guidelines:

- It must run under DOS. UCSD Pascal was not reviewed in 1984 because its environment, the p-System, was its own operating system at that time; today, the p-System is a shell running over DOS, and its compiler includes an 8086 native code generator.
- It must be a fully vendor-supported product with telephone support available either free or on a subscription basis. User-supported or public-domain compilers are not included. Pascal/MT+86 is not reviewed because DRI no longer supports it via telephone. (DRI claims it will support the product through the mail.)
- It must be intended primarily for software development rather than the teaching of Pascal. The three teaching products, Alice Pascal by Software Channels, Exploring Pascal from Ashton-Tate, and WATCOM Pascal, are described in the accompanying sidebar.
- It must be generally available to end users and cost no more than $1,000. OEM-only or bundled Pascal compilers are not included.

THE PORTABILITY PROBLEM

Pascal suffers from the lack of a useful standard. While two standards exist, ANSI/IEEE 770 X3.97-1983 and ISO 7185, neither specifies a language in which commercial software can be developed. Wirth's response to early criticisms of Pascal's incompleteness was

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not to improve Pascal but to present Modula-2 as an alternative. In the meantime, Pascal has been filled out to commercial usability by its implementors, each with a slightly different philosophy. It is thus the least portable of the major programming languages.

Two different kinds of portability are involved. One, which could be called *vertical portability*, is concerned with a given program source compiling identically under different Pascal compilers. As anyone who has tried to convert a complicated program from MS Pascal to Turbo Pascal will attest, vertical portability can be approached but rarely achieved. *Horizontal portability* is identical compilation across different machine environments, such as the IBM PC under DOS, an AI workstation running UNIX, or a VAX minicomputer running VMS. Horizontal portability would seem more difficult than vertical, because it must address fundamental differences between computers and operating systems, but it has actually been accomplished by clever work on the part of several vendors, most notably Pecan Software Systems.

In practice, roadblocks to Pascal portability involve both horizontal and vertical elements. The best example is in file support. Standard Pascal defines a reasonable identity to only two files, Input and Output. No facility exists for connecting a logical to a physical file; an assumption is made that when the program takes control of the machine, operating system primitives have already connected Input and Output to physical files. Logical files can be created within a program using the Rewrite command, but connecting the new logical file to a physical file is left to the operating system and cannot be done under program control.

Files cannot be opened for update in standard Pascal. A file opened for input is considered read-only; a file opened for output is cleared of all previous contents. Standard Pascal has no random file support and no way to close a file. No provision is made for trapping file system errors. Remarkably, no provision whatsoever is made for separate compilation or libraries. Variable-length string processing is another omission. Screen formatting support is absent, aside from a method of specifying a field width for the display of variables. Note that these are not merely niceties but essential elements in the creation of commercial software.

Obviously, Pascal portability cannot be achieved by close attention to an established standard, as is possible with COBOL and FORTRAN. Extensions are required to get the job done. Pascal developers must decide how important portability will be to their applications and act accordingly. Developers whose market is solely within DOS might be interested in maintaining some measure of compatibility across several different compilers in case the vendor of their development compilers goes bankrupt or abandons the product.

Vertical portability can be approached by isolating nonstandard language functions in a separate set of procedures and functions that can be identified as a group, perhaps as a library or a source code include file. Then, in moving a program from one compiler to another, the majority of coding changes can be confined to the library or include file.

Programmers developing an application for a narrow, vertical market must try for horizontal portability as well. While IBM hardware may have an overwhelming penetration of the overall business market, within a narrow niche the mix can be highly unpredictable, and supporting more than one operating environment may mean the difference between a product that will succeed and one that will not.

Pascal has been filled out to commercial usability by its implementors, each with a slightly different philosophy. It is thus the least portable of the major languages.

Horizontal portability is best achieved by coding in a dialect of Pascal supported by the same vendor in each desired machine environment. Microsoft Pascal is available for both DOS and XENIX, and Turbo Pascal supports DOS, CP/M-86, and CP/M-80. UCSD has made horizontal portability its trademark by supporting nearly every microcomputer in common use, as well as several minicomputers and a few mainframes (see table 1).

EVALUATION CRITERIA

At the highest level, software is evaluated by asking two questions: how well does the software achieve its own goals and how well does it satisfy the needs of a given audience? For the purpose of this review, the audience is the professional applications developer who creates software either for sale or for internal company use. Pascal is viewed primarily as an applications language—that is, the ability of a compiler to generate device drivers is less important than its ability to handle files efficiently and numeric values accurately. Professional systems programming, on the other hand, is nearly always done in assembly language or C.

Keeping these factors in mind, this review evaluates Pascal compilers based on the following criteria.

The shape of the system. To the traditional filter-type compiler/utilities package has been added the integrated programming environment: a single program incorporating a text editor, compiler, and associated utilities, all designed to work together seamlessly in pursuit of greater programmer productivity. Mystic, Turbo, and UCSD Pascal follow this model; the others are filters.

The advantage of a filter-type compiler is that it can be called from batch mode. This is especially critical when separately compiled applications expand across many modules and the link step becomes complex. IBM, MS, and Professional Pascal work well from batch mode, but Utah Pascal, while a filter-type compiler, has a proprietary interactive linker that cannot operate from batch mode—thus giving it the worst of both worlds.

An environment must be able to switch quickly between utilities or it loses much of its advantage. UCSD Pascal suffers here, because it must load its utilities from disk (rather slowly, in fact) and run them. Mystic and Turbo Pascal are entirely RAM-resident and move among screens instantly.

Another issue is the power available from within the environment. An environment must either allow access to DOS utilities or provide reasonable power on its own. UCSD Pascal has the ability to execute p-System programs (but not DOS programs) from within the environment. Mystic and Turbo Pascal lack this ability. Hot-key invoked RAM-resident utilities, such as Software of the Future's WindowDOS, make this problem less limiting than it once was.

Generated code options. All the compilers tested except Utah Pascal are able to generate native 8086 code. Intermediate code, the primary option of UCSD Pascal and the sole option of Utah Pascal, offers compactness and portability but requires the presence of an interpreter at runtime. If the cost of this interpreter

TABLE 1: *Features Comparison*

	IBM	MS	MYSTIC	PRO.	TURBO	UCSD	UTAH
VERSION	2.0	3.31	1.5B	2.5	3.01A	4.4G	4.1
PRICE	$385.00	$300.00	$16.00/ $32.00[a]	$595	$69.95	$79.95	$39.95
COMPILER SHAPE AND OPERATION							
Compile from batch mode	●	●	○	●	○	○	●
Full screen support	○	○	○	○	●	●	○
Graphics support	○	○	○	○	●	●	○
Large memory model	○	●	○	●[b]	○	—	—
Native code generator	●	●	●	●	●	●	○
.OBJ file generator	●	●	○	●	○	○	○
Overlays	●	●	○	●	●	●	○
Produces stand-alone program files	●	●	○	●	●	○	○
Separate compilation	●	●	○	●	○	●	●
Text editor	○	○	●	○	●	●	○
NEC processor support	○	○	○	●	○	○	○
186/188 and 286 optimizations	○	○	○	●	○	○	○
NUMERIC SUPPORT							
8087 detection	●	●	○	●	○	○	○
8087 support	●	●	○	●	●	●	
BCD math	○	●	○	○	●	●	○
BYTE type	●	●	○	○	●		○
Long integers	●	●	○	●	○	●	○
Unsigned integer (WORD type)	●	●	○	●	○	○	○
FILE SUPPORT							
Path support in file I/O	●	●	●	●	●	●	○
Random files	●	●	●	●	●	●	●
Open for update	●	●	●	○	●	●	●
DATA EXTENSIONS							
Conformant arrays	●	●	○	○	○	●	○
Procedural parameters	●	●	○	●	○	●	○
Variable-length strings	●	●	○	●	●	●	●
FLOW OF CONTROL							
BREAK statement	●	●	○	○	○	○	○
Concurrent processes	○	○	●[c]	○	○	●	○
CYCLE statement	●	●	○	●	○	○	○
In-line machine code	○	○	○	○	●	○	○
Interrupt procedures	○	●	○	●	○	●	○
LOW-LEVEL SYSTEM HOOKS							
Absolute memory access	●	●	○	●	●	○	●
Absolute variables	●	●	○	○	●	○	○
Command line access	●	●	—	●	●	—	○
DOS calls	●	●	○	●	●	●	●
DOS condition code return	○	●	○	●	●	●	○
Interrupt calls	●	○	●	●	●	○	○
Port I/O	●	○	○	○	●	○	●
ENVIRONMENT							
Disk space required	720KB	720KB	360KB	4MB	360KB	720KB	360KB
RAM required	256KB	256KB	256KB	512KB	64KB	128KB	128KB
Link-compatible HLLs	IBM FORTRAN	MS C, FORTRAN	None	Hi-C	None	UCSD BASIC, FORTRAN	None
Environments supported in addition to DOS	None	XENIX 286	None	VAX/VMS, UNIX	CP/M-86, CP/M-80	—[d]	CP/M-80[e]

● = Good ○ = Bad — = Not applicable

[a] *$16 for documentation on disk; $32 for printed documentation*
[b] *Also supports small, compact, medium, and big memory models*
[c] *Not fully implemented in this release*
[d] *Amiga, Atari ST, VAX/VMS, UNIX System IV, DEC RT-11/TSX/RSX/RSTS, MSX, Stride, IBM Displaywriter, Altos, and others*
[e] *The CP/M-80 version of Utah Pascal is currently sold as Nevada Pascal*

Memory model is difficult to define for interpreted products. Likewise, programming environments are not command-line driven, so command-line access is undefined for programs that are executing within an environment.

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is high, then developing applications under the compiler in question can end up being uncompetitive.

For the native code generators, the 8086 provides several memory models, which are ways of arranging code and data relative to machine registers. The small model (as seen in Turbo Pascal) limits usable RAM and makes large applications impractical. The majority of the compilers provide some sort of large memory model allowing most or all of RAM to be used, but only Professional Pascal allows a choice of models.

Other considerations are support for the 8087 or 80287 coprocessor and a linkable object format. All compilers except Mystic and Utah Pascal support the 8087/287 in some fashion. UCSD and Utah Pascal have proprietary linkable formats available only to themselves. (UCSD Pascal will link, however, with other p-System compilers.) Only IBM, MS, and Professional Pascal support Microsoft's standard .OBJ format.

Performance. Compile speed must be considered in relation to the value of the programmer's time. Turbo Pascal was designed to optimize the development cycle for speed; no other product comes close to its speed for the writing and testing of code. On the other hand, a slow compiler must generate excellent code, with intelligent optimization and access to all available machine resources. Finally, reliability is extremely important. With the exception of Mystic Pascal, all of the compilers reviewed produce very reliable code.

Numeric support. Pascal is widely used in scientific programming, so richness of numeric support is important. To the standard integer and real types have been added unsigned integer (Word or Cardinal) types and the unsigned 8-bit integer subrange (Byte) type. Several compilers provide long (usually 32-bit) integer types, and UCSD Pascal has a variable-precision integer offering up to 36 significant figures.

The precision and range of implemented real types vary widely; attention should be paid to whether a compiler supports the IEEE standard real number formats. Some speed can be gained in real operations by implementing real numbers in fewer bytes than the widely used 8-byte IEEE real. Turbo Pascal's standard real is 6 bytes, and Microsoft offers a fast 4-byte real as an option.

Finally, business programming requires some means of expressing very large values (these days, up toward the trillions) with absolute precision. Most compilers provide binary-coded decimal (BCD) math of some sort, typically as a proprietary real number format stored as a fixed-point decimal rather than floating-point value.

File support. Pascal's standard file support is notoriously minimal. As mentioned earlier, portability of file code is difficult, and close attention must be paid to the syntactic details of file access. Some de facto standards have emerged, including the Seek procedure for random I/O, but similarities appear mostly in the broad strokes; quirks and nonstandard extensions abound.

All compilers except Professional Pascal can open a file for update—that is, for write after read. Turbo and UCSD have untyped file support for reading files as blocks of raw data. Usable applications require that file status information be communicated to the program from the operating system. Most compilers can report errors from the operating system. Only a few can report in any detail what went wrong.

Variable-length string handling. Conveniently representing text within a program is next to impossible without support for variable-length strings. UCSD Pascal set a strong and early standard

When compared to other programming languages, the quality of a typical Pascal compiler's documentation is very good indeed.

with its scheme, in which strings are arrays of characters with a leading length byte reflecting changes in the logical length of the string as various operations are performed on it. UCSD's suite of string primitives has been imitated by some compilers, including Turbo and Utah Pascal. MS and Professional Pascal implement similar string types and functions, but their syntax is significantly different. Only Mystic Pascal lacks variable-length strings.

Separate compilation. Once a program grows beyond a few thousand lines, efficient development becomes exponentially more difficult without separate compilation. The power of a separate compilation scheme can be a limiting factor in the size and complexity of an application. A scheme that is compatible with Microsoft LINK can avail itself of third-party linkable libraries that are targeted for MS Pascal.

Most compilers that support separate compilation use some variation on a system pioneered by UCSD Pascal and adopted to some extent by Wirth's Modula-2. This is the *unit* concept, in which a compiland has two source modules: an interface part giving explicitly public identifiers and calling syntax, and an implementation part containing the actual private code and data definitions. Beyond this, a good scheme should address the problem of identifier name conflicts across independent linkable libraries created in ignorance of one another. By far, the best such system is Professional Pascal's.

Overlays are often implemented as a variation of separate compilation. Units in UCSD Pascal may be loaded on demand. Turbo Pascal's overlay scheme, which is the closest the product comes to separate compilation, enables a small-model program to incorporate (at least theoretically) as much code as the disk is able to hold.

Low-level hooks. Portability was once achieved by ignoring all but the most generic features of the computer. Today's competitive market makes this impossible. Screen control, I/O-mapped peripherals, and interrupt-driven peripherals all must be controllable by a program. Allowing linking to assembly language driver subprograms minimizes the need to extend the language but leaves more work to the developer.

Turbo Pascal, lacking separate compilation, has gone to greater lengths than all the other compilers to incorporate low-level hooks in the language. UCSD Pascal provides its very complete system access in the form of linkable libraries. The other compilers typically lack system hooks much beyond a generic DOS call routine and memory access through special pointer instances.

Documentation. Compared to other languages, the quality of a typical Pascal compiler's documentation is very good. With the exception of Mystic Pascal, all the products provide indexes—and Professional Pascal's index is nothing short of spectacular. Most documentation is divided into two portions: generic information about the implementation of the language and information on running the compiler in a specific operating environment. The aim is to provide a single reference manual for any implementation of the same compiler, plus a user's guide for each separate implementation, outlining the quirks imposed upon an implementation by details of the operating environment.

MS, Professional, and UCSD Pascal get very high marks for their documen-

tation. IBM's is mediocre. Turbo Pascal's is hurt by frequent typographical errors and a somewhat confusing organization, as well as a lack of adequate examples for arcane compiler features. Utah and Mystic Pascal provide documentation that is generally insufficient.

Price and support. The price range of these Pascal compilers is considerable—from $16 to $695. Conventional wisdom dictates that the higher the price, the better the support. This is not necessarily the case, as shown by Borland's superior telephone support of a product costing only $69.95.

The vendors do not charge for their baseline telephone support, but long periods on hold and frequent "I'll check and get back to you" comments can be expected from time to time. Nonetheless, current telephone support of Pascal products is enormously better than three or four years ago when it was little more than message-taking for overworked staff programmers. Microsoft has a subscription ISV (independent software vendor) support program for all its language products.

Upgrade policies vary widely from vendor to vendor, and even a single vendor's policies change from upgrade to upgrade. Microtec Research has a 12-month warranty on its disk media, but replacement disks and updates cost $50. Microsoft updates vary in cost, depending on the quantity of materials involved. Its minimum charge is $25. Borland has offered upgrades of the entire Turbo Pascal package (including documentation) to registered users for significantly less than list price.

Support also can include independent user groups, bulletin boards, and third-party books and tutorials. Numbers are the important factor here, with the most nonvendor support lining up behind Turbo Pascal.

CONSIDERING BENCHMARKS

Benchmarks, like statistics, should be viewed carefully in context and examined for what they do not say as much as for what they do say. A good benchmark should highlight program bottlenecks, typically tasks that are very necessary and done very frequently. The benchmark program Bencher provides ten such tests, along with the Sieve of Eratosthenes. Listing 1 is Bencher implemented for MS Pascal. Implementations for the other compilers are nearly identical, with most deviations occurring in file access syntax.

Listing 2 is a benchmark program called Matrix borrowed with permission from *Pascal Programs for Scientists and Engineers*, by Alan R. Miller (Sybex, Inc. 1984). Again, it is for MS Pascal, and the others are nearly identical. Matrix multiplies two 20-by-20 arrays of real numbers ten times. Its value as a benchmark is that it does a great deal of real number arithmetic without using standard real number functions that are traditionally implemented as library routines. It should thus be a good test of in-line real number code generation.

The first benchmark in Bencher tests screen display speed by writing 1,000 64-character strings to the screen. Most business applications spend a great deal of time painting screens. In terms of user satisfaction with the final product, this factor can be critical.

The next two tests work together: one builds a 1,000-node linked list, and the other disposes of the list. The time spent here must be weighed against whether a given compiler uses 16-bit offsets or 32-bit addresses for pointers. While 16-bit pointers are faster, they may limit the user to less heap than an application requires.

The price range is considerable—$16 to $695. Conventional wisdom dictates that the higher the price, the better the support. This is not necessarily the case.

Bencher includes two tests to measure generated code's efficiency at calling and returning from subprograms. The first test calls an integer function with a null body and without parameters and is a measure of the efficiency of instantiating a stack frame and disposing of it again. The second is a procedure call with 85 bytes of parameters. This byte count varies among compilers due to differences in implementation sizes of real numbers and pointers. The test actually measures how well the code can move parameters onto the stack; TestProc has a null body and does not use the parameters.

The next test is straightforward; it measures 10,000 evaluations of the expression, Sqrt(Sin(Ln(3.14159))). Variations indicate more than just code efficiency, and may also show differences in real number size (4- , 6- , or 8-byte reals all exist), coprocessor use, and the quality of the standard function library. Most transcendental function libraries are written in assembly language for greatest speed, but some, notably UCSD's and Utah's, are written in Pascal.

Tests are included in the Bencher program to measure file system performance. One benchmark creates a text file and sequentially writes 1,000 64-character text lines to the file using Writeln. Another test opens the same text file and reads the 1,000 text lines back from disk via Readln.

Two tests measure the performance of binary and random file I/O. A binary file of records of 70 bytes (again, this figure varies depending on the real number size in the compiler configuration) is created, and 1,000 records are sequentially written to the file. Most compilers use Put for this purpose, but some, including Turbo and Utah Pascal, use a variant of Write. For the last test, this binary file is opened and an update-in-place is performed on each record, meaning that each record is read, modified, and written out again to the same position in the file. This operation is performed from the last record in the file to the first record, using whatever facility a compiler has available for performing random file I/O.

The Sieve of Eratosthenes is provided here largely to aid in comparing these results with previously published benchmarks in other publications. The Sieve is demonstrative of a compiler's performance in only the narrowest of terms—mainly array indexing and integer arithmetic. From time to time, rumors circulate that compilers are being written with "sieve recognizers" that identify the classic Sieve source and generate an array of primes from a table stored in the runtime library.

With some compilers, buffering can be adjusted to optimize disk performance. All benchmarks were executed with the default values for file buffering and with error trapping disabled. When the option was available, the compilers were directed to generate 8087 in-line code rather than runtime 8087 detection and emulation.

All the benchmarks were run on the same machine, an IBM PC with 640KB of RAM, 4.77-MHz 8088, 8087 coprocessor, two half-height floppy disk drives, and a single 20MB hard-disk subsystem from PC's Limited. For time testing, a subdirectory called TIMETEST was created when the hard disk was about 60-percent full. Compilers and source code files were moved into TIMETEST, timed, and erased; therefore, all of the disk-bound timings represent

TABLE 2: *Benchmark Timings*

	IBM No 8087	IBM With 8087	MS No 8087	MS With 8087	MYSTIC	PRO. (Small model) No 8087	PRO. (Small model) With 8087
BENCHER.PAS							
Compile time	1:55.17	1:48.03	1:36.72	1:34.36	0:03.74	1:59.40	1:47.92
Code file size	36,612	28,212	42,376	42,040	7,456	29,906	23,906
Screen display	1:58.90	1:58.97	2:20.23	2:20.23	0:09.12	2:16.27	2:16.22
Build list	0:01.04	0:00.99	0:00.49	0:00.49	—[a]	0:01.48	0:01.43
Dispose of list	0:00.11	0:00.06	0:00.55	0:00.55	—	0:00.66	0:00.60
Function call	0:01.82	0:01.81	0:01.76	0:01.81	0:06.76	0:02.03	0:01.97
Procedure call	0:09.88	0:09.97	0:09.94	0:09.94	3:04.33	0:09.12	0:09.06
Transcendental functions	10:13.95	0:16.54	10:23.68	0:17.24	9:16.56	15:48.90	0:10.65
Sieve	0:11.04	0:11.10	0:10.99	0:10.99	0:35.65	0:12.14	0:12.79
Text file write	0:13.08	0:13.01	0:08.95	0:09.01	0:05.87	0:04.07	0:04.01
Text file read	0:16.03	0:15.98	0:17.30	0:17.24	—[b]	0:04.95	0:04.94
Binary file write	0:06.92	0:07.19	0:06.64	0:06.64	0:07.41	0:04.12	0:03.85
Binary file update	0:25.87	0:24.06	0:27.02	0:26.92	0:18.89	—[c]	—[c]
MATRIX.PAS							
Compile time	1:37.38	1:31.72	1:21.61	1:19.03	0:02.25	1:55.83	1:46.11
Code file size	40,626	33,906	46,294	45,782	3,696	32,882	28,178
Matrix multiply	0:21.14	0:02.31	0:21.03	0:02.53	0:13.45	0:19.01	0:02.75

[a] *Heap support was not implemented at review time.*
[b] *Mystic Pascal does not support line-oriented text file read.*
[c] *Professional Pascal does not support update-in-place with standard record oriented file primitives.*
[d] *Timings are the same as UCSD native code.*

accesses to roughly the same regions on the disk. The benchmark results are presented in table 2.

The PC's built-in timer was used whenever possible to deliver an accurate elapsed time figure for the software benchmarks. For the benchmark programs themselves, the procedure Show_Time was written; it does nothing more than read the current time from the system clock via DOS function 2CH and write the time to a text file. Show_Time resolves to a PC timer tick—1/18 of a second. The code that is to be timed is bracketed by two invocations of Show_Time. The difference between the two times is a reasonable representation of the time taken by the bracketed code.

For filter-type compilers (IBM, MS, Professional, and Utah) a batch file similar to the one shown in listing 3 was used to bracket the compile/link commands with two DOS TIME commands. The first sets the timer to 0:0:0.0; the second displays the system time when the batch file is finished, giving a fairly accurate elapsed time figure for the compile operation.

A stopwatch had to be used for two of the environment-type compilers (Turbo Pascal and UCSD Pascal). The figures shown in table 2 are averages of three identical runs on each timed operation. Mystic Pascal times itself as it compiles, with the caveat that a considerable portion of its compilation effort is done while the code is being edited.

Interpreting the benchmark timing table must be done with the knowledge that any two readings that vary by less than .12 seconds must be taken as equivalent. One timer tick occurs every .06 second, so there is a .12 second window around any event during which another event can fall with no assurance that even a single timer interval (two ticks) separates them.

Finally, keep in mind that performance differences of less than 100 percent rarely create an overwhelmingly obvious difference in response in interactive applications (see "V20 Compatibility and Performance," Ted Mirecki, April 1986, p. 78). Raw performance figures should never be the first consideration in choosing a Pascal compiler. In fact, reliability, richness of features, ease of use, and quality of documentation may be considerably more important than speed. The Pascal compilers reviewed below are examined on the basis of all these factors. The order in which the products are presented is by market niche and does not reflect any judgment as to quality.

MICROSOFT PASCAL

Many people consider Microsoft's compiler the official Pascal for the IBM PC, because IBM distributes a version under its own label. It was certainly the first Pascal to be available under DOS, and in many ways it has improved more than any other Pascal reviewed here since its first release.

This is a two-pass, filter-type, native code compiler, invoked from the DOS command line and used from within a batch file. An optional third pass produces an assembly language type object code listing. The compiler's output is native code relocatable object (.OBJ) files in the Microsoft standard format.

The compiler's first pass is its *front end*, common to all implementations of MS Pascal and producing a tokenized output file. It can be used alone to check syntactic correctness quickly without spending time generating code. The second pass is the *back-end* optimizer and code generator pass, specific to an operating environment, such as DOS on the 8088. A final step using the DOS LINK utility is necessary to link a compiled program to the compiler's runtime library and any previously compiled or assembled external routines. The linker produces an .EXE file that can be run from the DOS prompt.

Beginning with version 3.3, MS Pascal's memory model changed from medium to large, as Microsoft pursued its policy of high-level language integration (see "Language Integration," Product of the Month, this issue, p. 29), allowing code written in MASM-compatible assembly language, MS Pascal, MS FORTRAN, and MS C to be linked freely into the same program module. MS Pascal supports only the large model; medium is no longer available. The default heap is short (16-bit pointers), but a library supporting the long heap (32-bit

PRO. (Large model) No 8087	With 8087	TURBO No 8087	TURBO With 8087	UCSD p-code	UCSD Native	Native With 8087	Native (DOS bridge)	UTAH
2:03.74	1:53.20	0:04.64	0:04.53	0:38.87	1:42.63	1:44.32	—[d]	1:17.81
43,154	34,434	14,936	13,585	3,584	4,608	4,608	—	3,072
2:16.76	2:16.71	1:41.18	1:41.23	0:28.78	0:28.56	0:28.50	—	3:04.49
0:02.25	0:02.19	0:00.55	0:00.55	0:07.25	0:06.98	0:06.97	—	0:03.36
0:01.65	0:01.70	0:00.71	0:00.66	0:10.60	0:10.38	0:10.38	—	0:02.09
0:02.09	0:02.08	0:03.52	0:03.52	0:22.14	0:09.44	0:09.40	—	1:39.31
0:09.72	0:09.78	0:15.87	0:16.14	0:42.57	0:26.37	0:23.29	—	2:54.30
19:10.42	0:11.48	6:09.76	0:10.72	10:00.11	9:56.60	0:38.73	—	3:57:27.62
0:12.08	0:12.14	0:13.84	0:13.89	2:02.43	0:15.21	0:15.22	—	8:21.69
0:05.54	0:05.55	0:10.05	0:10.05	2:28.35	2:39.89	2:19.02	0:30.54	0:25.81
0:05.22	0:05.22	0:09.56	0:09.56	0:19.06	0:17.03	0:20.48	2:16.54	0:29.11
0:04.12	0:04.18	0:06.26	0:06.54	1:17.33	1:16.57	1:11.52	0:24.67	0:28.01
—[c]	—[c]	0:15.38	0:16.37	1:51.72	1:50.45	1:53.20	1:13.38	1:27.66
1:59.62	1:50.61	0:03.61	0:03.65	0:24.83	1:20.08	1:21.72	—	0:39.93
44,946	38,722	13,574	12,187	2,048	3,072	3,072	—	1,664
0:23.50	0:02.74	0:09.94	0:06.27	0:24.72	0:08.89	0:04.07	—	0:39.93

Compile times for the two environment products Turbo and UCSD Pascal were taken with a stopwatch; Mystic Pascal contains a built-in compiler timer. IBM, MS, Professional, and Utah Pascal were compiled from batch mode and then timed with DOS's TIME command. All code timings are from the system timer through DOS function 2CH, Get Time.

pointers) is included. Also, beginning with version 3.3, programs compiled under MS Pascal cannot be run under DOS 1.x. IBM Pascal, which still supports 1.x, should be used if such support is required of an application.

A profusion of numeric formats and types gives the programmer a great deal of control over the speed and precision of numeric operations in MS Pascal. Three different signed integer types are predeclared: Integer1, a signed 8-bit integer ranging from –127..127; Integer2 or Integer, the familiar signed integer type; and Integer4, a 32-bit signed long integer type with a range of –2,147,483,647..2,147,483,647 ($\pm 2^{31}-1$). Subranges are not allowed on Integer4, nor can it index arrays. Two unsigned integer types, Byte and Word, occupy one and two bytes, respectively. The rules of how these various types can be combined in expressions and which automatic conversions are done reflect the realities of code generation more than any intuitive plan. For example, Integer freely converts to Real in expressions when such a conversion does not violate the mathematical sense of either type, but Integer4 must be converted to Real using a library routine.

The situation for real number formats is more complicated still. The standard Pascal type Real can be expressed as either a 32- or a 64-bit IEEE format by specifying the format in a compiler command. Additionally, 4- and 8-byte reals may be mixed within a program by explicitly declaring values as Real4 and Real8; both formats are fully compatible with one another. Real8 is the familiar IEEE 64-bit format used by the 8087. Real4 uses a 24-bit mantissa and 8-bit exponent, giving seven significant figures and a range of 10^{-38} to 10^{38}. Real constants are always expressed in the 64-bit format.

MS Pascal provides a floating-point decimal real type with 14 significant figures of absolute precision. Any value requiring 14 or fewer significant figures can be represented exactly, supporting values up to $1 trillion to the penny. If precise representation is not required, the exponent range extends from 10^{-63} to 10^{63}. This numeric type is poorly described in the documentation.

Finally, MS Pascal offers an "alternate math package" (ALTMATH) that trades precision for speed in systems that do not include math coprocessors. ALTMATH does not support the infinite stack provided by the 8087 emulator match packages and is not well documented at all with regard to available precision or internal expression of values. It runs faster than the 8087 emulator, but not as fast as code that takes advantage of the 8087 itself.

The runtime support for reals is sophisticated enough to sense the presence of an 8087 in a system and use it if it exists or emulate it if it does not. A compiler command can force the generation of in-line 8087 code for faster operation (this is how the 8087 benchmarks for MS Pascal were generated), but the resultant program will hang a system without an 8087.

MS Pascal supports all standard file operations as well as extended file support for physical file assignment, file closing, file deletion, and random file I/O. Files may contain up to 2 billion records (Maxint for Integer4). File error conditions may be trapped and tested without allowing runtime errors to disrupt operation of the program. The file system's only lack is an untyped file in the Turbo Pascal style, through which raw sectors may be retrieved with great speed from the disk without typing or other interpretation.

MS Pascal's file support performance is disappointing, given the product's performance in other areas. At best, it equalled or slightly exceeded Turbo Pascal in speed, falling to about half Turbo's speed for reading text files. It failed even to approach Professional Pascal's file I/O in all categories.

Conformant arrays are implemented as a *super array* extension to standard Pascal. The upper bounds of super arrays are not set at compile time. They are a "type of types" that is compatible with derived array types, the upper bounds of which are set in their declarations. Super arrays can act as subprogram formal VAR parameters, and they also can be allocated dynamically on the heap. A built-in function called Upper can be used within a subprogram to determine the upper bound

PASCAL TOOLS FOR LEARNING

I learned Pascal as I learned to swim; I bought a compiler, jumped in, and thrashed around until I was confident I would not drown. This approach has two problems: (1) it takes longer than it should, and (2) it can develop peculiar programming habits. Without a curriculum, a person rarely learns the *entire* subject. Pointers and Get/Put seemed arcane, so I ignored them, using arrays and the compiler's proprietary random file syntax instead. Years passed before I bothered to study forward declarations.

Behind most languages, and Pascal in particular, is a design philosophy in which all parts of the language play an integral part. Programming with part of Pascal is simply not as effective as with *all* of it. Three Pascal interpreters/tutorials for DOS are available to aid the learning process.

Exploring Pascal. Exploring Pascal is a recent offering from Ashton-Tate. It consists of a sturdy 420-page book and a single unprotected diskette. While the book is handy as a ready reference and for getting started, it becomes extraneous once the learner gets caught up in the on-line tutorial.

The software is a simplified programming environment, modeled after UCSD Pascal. It implements most of standard Pascal but virtually nothing more; Niklaus Wirth would approve. From the main menu (arranged along the top of the screen, UCSD-style) the user can enter the editor, compiler, filer, or the on-line tutorial.

The compiler supports a very simple superset of the language, adding only UCSD-style, variable-length strings and random file I/O. It compiles to an intermediate code that is interpreted by the environment. An optional optimizer pass makes code files a little faster and more compact, but not enough to merit the added complication to the system.

The tutorial is classic computer-assisted instruction: screens of lecture followed by exercises. The screens are clearly and crisply written, and the exercises reinforce the material. Use of color is excellent. Some of the tutorials have animated code examples in which a reverse-video bar highlights the executing statement of a FOR loop in slow motion to explain how loops operate (see photo 1).

One irritation is that some technical terms are given odd definitions. For example, the author refers to human-readable reserved words and identifiers as *tokens*, a word most people take to mean a binary code for an identifier or reserved word after some compilation has occurred. The book also lacks an index, although the table of contents is detailed enough to serve a similar function.

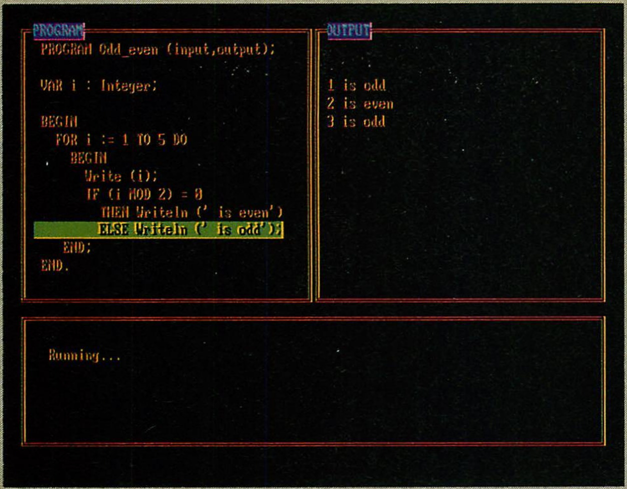
The two main problems of Exploring Pascal are not really germane to its stated purpose of teaching a beginner to program in Pascal. First, a source file cannot be imported from another compiler unless the file is syntactically correct from Exploring Pascal's point of view. The error message in such a case is abominable: "ERROR: File damaged in file: 'BENCHER.PAS'." A syntax error is not the same as a damaged file, and a beginner is bound to get very nervous when confronted with this message. Furthermore, no clue is given as to what is wrong with the incorrect file. Second, the system is rather closed-ended. It has no cursor positioning ability and no means to build one out of BIOS calls or DMA to the screen. Therefore, building anything but toy programs is impossible.

The bottom line on Exploring Pascal is that it is likely to be used only once. After a person has run through the tutorials and compiled a few demo programs, restlessness will set in, and the user will want to graduate to a "real" Pascal. Taking that first step is never easy, however, and Exploring Pascal will help the new programmer take it correctly.

WATCOM Pascal. In the same way that the University of California at San Diego spun off SoftTech Microsystems to market university-developed UCSD Pascal, so did Canada's University of Waterloo create WATCOM Systems to sell its line of language products, including its Pascal interpreter.

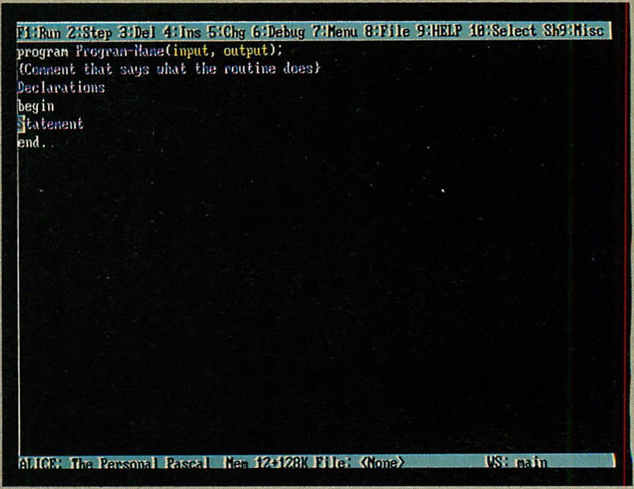
WATCOM Pascal is a programming environment incorporating an editor, interpreter, and debugger. The bottom line of the screen is a command line, with the remainder of the screen given to the editor and to program

PHOTO 1: *Exploring Pascal Tutorial*



The green bar moves through the code example, highlighting statements as they are executed.

PHOTO 2: *Alice Pascal Template*



The programmer replaces the blue place holders with valid program reserved words and identifiers.

execution. Source code in the editor is not explicitly compiled, but is interpreted when the Run command is given. As with BASIC, true interpretation means that syntax errors are not always found until runtime.

The editor is function-key driven and has a very intuitive design. Like Turbo Pascal, it does not correctly expand tab characters from imported code. A diagram of function key meanings is always available by pressing F10, and help screens are accessible for most of the editor's (but not the language's) features.

The interpreter extends a fairly complete implementation of standard Pascal with full screen control, strings, random file I/O, peek, poke, time and date functions, DOS calls, hooks to user-loaded machine-code routines, and a superb set of graphics routines. No bugs were discovered in either the environment or interpreted code.

The debugger allows immediate execution of complete Pascal statements, single-stepping of a program, and examination and alteration of program variables. One of the debugger's virtues is its simplicity, which makes it understandable to beginners.

This very capable software is spoiled by a terribly written tutorial. It suffers from bad writing—gramatically correct but devoid of any feeling for the big picture of Pascal. The discussion of Boolean variables and expressions gives a correct description of Pascal's Boolean type without any higher-level explanation of where the type came from nor what it is for. So it continues throughout the tutorial. A newcomer to Pascal could carry away enough details to pass a first-year computer science exam, but no true understanding of the language would gel out of this relentless and unstructured progression of facts.

Annually renewable site licenses are available that favor large educational customers, and the software includes an expiration-date scheme that renders it unusable after a certain preset date. At its undated single-copy price of $225, WATCOM Pascal is far more costly than its power merits.

Alice Pascal. Alice Pascal, from Software Channels, is a far more ambitious product than either WATCOM or Exploring Pascal. Like WATCOM, it comes from Canada; in fact, it was created as an alternative to WATCOM Pascal for the Canadian educational market. Like the other two interpreters, it is explicitly targeted at beginners, but it gives those beginners credit for considerable intelligence and allows for more of the inevitable curiosity about the underlying computer.

Alice is a programming environment constructed around a remarkable syntax-directed editor. The editor is both command- and menu-driven in that input may be either typed or selected from a hierarchy of pop-up menus. In editing a new program, the programmer begins not with a blank screen but with a template containing place holders for the essential parts of a Pascal program. The initial template is shown in photo 2. Words in blue are place holders, and editing a program is a process of replacing the place holders with appropriate program statements. Syntactically incorrect statements are detected immediately, highlighted in color, and explained with a detailed error message. When the user selects from a menu a program structure such as a case statement, a template for the structure appears, with more place holders waiting to be filled in. The template defines Alice's text-formatting conventions, including indentation and the number of lines between procedures and functions. Fortunately, the conventions can be modified by altering the shape of the templates used by the programmer.

Alice's templates can be filled in in two ways when writing a program. One is simply to type reserved words and identifiers into the template; the editor does its best to send the cursor to what it assumes is the desired next position. Tab and Shift-Tab move forward and backward along the template. Alternatively, nearly every item can be selected from a menu without explicitly typing it.

The syntax-directed editor is thus a tutorial of sorts, because it focuses on structure and syntax while the program is under construction, offering feedback while the program concept is fresh in the programmer's mind. The programmer can go off in one direction and the editor will follow, pointing out mistakes and the correct path in the same action.

Alice has room in memory for 1,600 lines of source code, so it can do more than teach the basics of Pascal, but it cannot rise above "recreational programming." Although programs written in Alice require the Alice environment to run, Software Channels is releasing a runtime version that may be distributed free with user-written programs.

Alice offers everything present in WATCOM Pascal and is much richer than Exploring Pascal; it includes full-screen control, access to the system clock, and many other features that allow truly interesting software to be written. It has a suite of built-in debugging tools, including source animated trace, and a respectable library of utility routines. Software Channels is moving Alice toward compatibility with Turbo Pascal. Future releases will include the ability to load and run Turbo's machine code external binary libraries such as GRAPH.BIN.

The Alice Pascal tutorial has a different focus from that of WATCOM and Exploring Pascal; it teaches the use of Alice rather than Pascal itself. It has no well-defined Pascal curriculum. This is not a crippling deficiency, given the three products' emphases: WATCOM and Exploring Pascal seem slanted toward the newcomer to programming, while Alice is slanted toward a computer-literate newcomer to Pascal. The material is more complex and powerful. An Alice textbook is in production, but was not available in time to review. Once it is, Alice Pascal will serve the same market as both Exploring Pascal and WATCOM Pascal—and serve it considerably better.

—Jeff Duntemann

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of an actual parameter that is passed through a super type.

MS Pascal's string types are derived from the super array concept. The String type is a pure super array of characters, and the LString type is a special super record having a leading length byte in addition to a super array of characters. LString is thus quite similar to the UCSD-style string used in several of the other compilers. The suite of procedures and functions acting on LString types, however, has different names, functions, and calling syntax, making MS Pascal's string handling less portable than the other compilers.

Like Turbo Pascal, MS Pascal supports array, record, and typed set constants, although its notation for structured constants is less intuitive and readable than Turbo's.

Separate compilation can be handled two ways. *Modules*, which are compilands containing external data and subprograms, amount to a program without a program body. This is the same method used with Pascal/MT+86. The better means is via *units*, which resemble modules as used by Modula-2. A unit has a definition part called an *interface*, which contains only the declarations of the unit's contents, and an *implementation* in which the data and subprograms of the unit actually reside. With units, the hiding of details in separately compiled items is complete. MS Pascal's unit concept is nearly identical to the one in UCSD Pascal.

Separately compiled modules (but not units) can be combined into libraries using MS LIB, a librarian utility bundled with MS Pascal. LIB also facilitates updates of modules contained within the library, without having to recreate the library from scratch.

MS Pascal's suite of low-level hooks is smaller than Turbo's, but the situation for MS Pascal is less serious because a programmer can write what is lacking in assembly language for inclusion in a library. MS Pascal has no I/O port access, no facility for in-line code generation, and no software interrupt call. A DOS call primitive exists, and separate functions returning date and time values are available. The Retype facility is more general and better documented than Turbo's, and free union variant records are supported. The Origin attribute allows variables to be declared at absolute memory locations. Documentation on writing external assembly language subprograms includes complete descriptions of the stack frame and of internal data representations for all but the real types.

Documentation for MS Pascal follows the common two-volume model: a reference manual for Pascal, divorced as much as possible from any particular implementation of the language, and a separate user guide for each implementation—in this case, one for DOS and one for XENIX. From a structural and organizational standpoint, the documentation is complete and proper. It has good tables of contents, indexes, listings of error messages, and so on. The pages are not overly crowded, and the text can be easily skimmed. No typographical errors are evident.

The problem with the text is a pervasive vagueness. For example, the user's guide mentions a pair of public variables, CRCXQQ and CRDXQQ, which hold register values after a DOS call, but the manual does not give their

Beginning with version 3.3, programs compiled under MS Pascal cannot be run under DOS 1.x. IBM Pascal, which still supports 1.x, should be used if such support is required.

type. Worse, it does not say which library contains them. Similar lapses occur throughout both manuals.

The telephone support people seem to know the product extremely well. A 90-day guarantee is provided for the media. Updates vary in cost depending on how many disks are involved and whether manual page updates are included. Several good books have been written about MS Pascal, and a fair number of third-party linkable libraries also are available for it.

MS Pascal makes few concessions to beginners—it is a complex, powerful tool for developing medium to large applications. For a product of its power and complexity, however, its learning curve is surprisingly short. While its price is on the high side (compared to the very capable Turbo and UCSD Pascal), it is not beyond reach of the serious personal programmer, and for the professional programmer it provides a better balance between cost and power than Professional Pascal, which offers its only real competition.

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IBM PASCAL

IBM Pascal is, in fact, a private-label packaging of Microsoft Pascal, with enough differences to warrant discussion in its own right. According to Microsoft, IBM Pascal 2.0 is a proper subset of MS Pascal 3.31, with the exception of three library routines. This discussion of IBM Pascal is limited to its differences from MS Pascal.

Whereas MS Pascal uses the large memory model, IBM Pascal uses the medium model. Assembly language modules that link with one compiler therefore will not necessarily link with the other. IBM lacks MS's integration with other Microsoft languages, including the C attribute that allows the declaration of procedures with varying numbers of parameters. IBM Pascal programs can link with object files compiled under IBM FORTRAN 2.0 (again, a variant of MS FORTRAN), but the documentation for that feature is so vague that such linkage is impractical for all but the inhumanly determined.

A set-up utility is included that automates the copying of files to working floppy or hard disks. This utility also configures the runtime library file by concatenating the user's selection of numeric and DOS version libraries with the standard runtime library into a single enormous library file. The aim is to simplify the link step, an admirable goal, but the utility insists on creating a hard-disk subdirectory called \PASCAL (or using one if it already exists) and does not allow the user to specify a subdirectory name. This feature of IBM Pascal is simply unacceptable.

IBM Pascal lacks the richness of numeric formats offered by MS Pascal. Neither MS's BCD math nor its fast alternative math package (ALTMATH) are available. IBM Pascal cannot determine at runtime whether an 8087/287 coprocessor is installed, using it if there and emulating it if not. The programmer must explicitly link a given program for one situation or the other.

Although both IBM and MS Pascal support overlays, the MS implementation is more elegant and considerably better documented. (The IBM documentation references a section on overlays that does not exist.) The IBM scheme must explicitly load overlaid code via a LOADER function. MS Pascal's scheme is handled entirely through the linker; one or more linkable object modules may be specified as an overlay file at link time. The MS compiler does not know about overlays, and identical source may be linked as overlaid or not, as desired.

IBM Pascal includes three important library routines that Microsoft Pascal does not offer: INP and OUTP, which are used to perform port I/O; and INTRP, which performs software interrupts from within Pascal code.

IBM's benchmark timings are not significantly different from Microsoft's in any area except dynamic memory management. IBM Pascal is only half as fast in building a linked list, but is several times faster than MS Pascal at disposing of the list.

One area in which IBM differs overwhelmingly from MS Pascal is documentation. Both vendors offer two separate volumes, a user's guide (IBM calls this guide *Pascal Compiler Fundamentals*) and a reference manual, but beyond that point the two have little in common. Microsoft splits its manual between describing MS Pascal and detailing its DOS or XENIX implementations, whereas IBM splits the manual between a guide organized into chapters by

IBM Pascal has three important library routines that Microsoft does not offer: INP and OUTP, which perform port I/O; and INTRP, which performs software interrupts from within Pascal code.

topic and an alphabetical key-word reference. Throughout both manuals the configuration is assumed to be the IBM PC, PC/XT, or PC/AT.

The IBM language reference for Pascal is very well done, in the fashion of the IBM BASIC manual. All key words and compiler directives are listed alphabetically, each with its own page. Skimming for a quick brush-up on an obscure compiler feature such as ACDRQQ (arccosine for real numbers) is fast, and references are given to related topics. Additionally, a table of contents with each key word and its page number is given at the front of the volume, as well as yet another section providing functional groupings of key words together with short descriptions—for example, a list of string functions, file management routines, etc.

Although the organization of IBM's volumes is somewhat more rational

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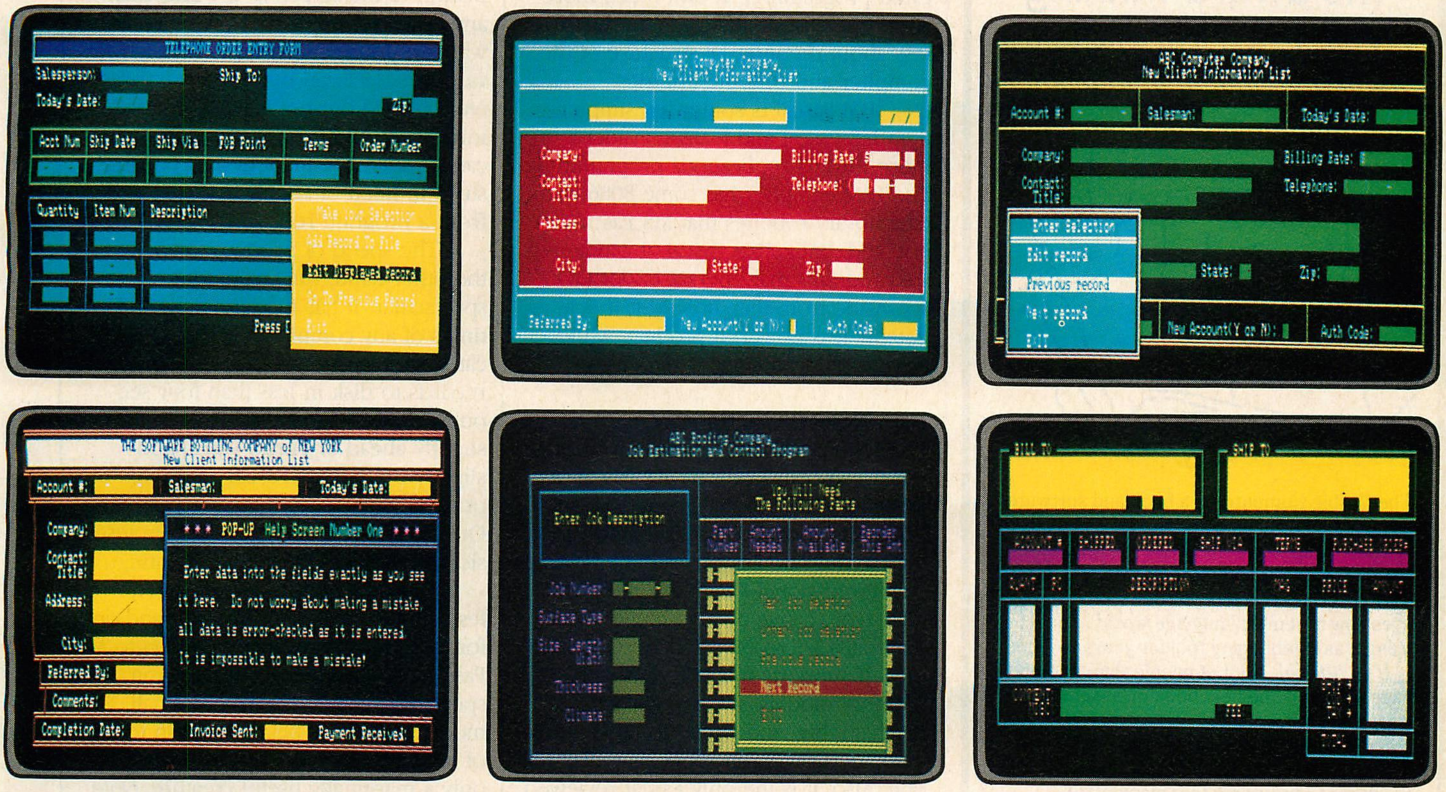

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than Microsoft's, it offers much less information. The more arcane features of the IBM compiler are covered minimally if at all. For example, IBM seems to have omitted any discussion of overlays. IBM's documentation seems consciously slanted toward a less sophisticated programmer. It says much more about the Pascal language and much less about the internal structure of the compiler and runtime libraries.

IBM Pascal is somewhat simpler than MS Pascal and leans considerably more toward applications programming. The IBM compiler has some 8086-specific library routines that MS Pascal does not, and, unlike MS Pascal, it can generate programs that operate under DOS 1.x. Aside from that, however, it is a notably less powerful product, while being significantly more expensive.

PROFESSIONAL PASCAL

Professional Pascal was conceived as an improved competitor to MS Pascal. Its designers tried to make sure that anything Microsoft's compiler could do, theirs could do faster and better.

Professional Pascal is a multipass, filter-type, native code compiler that generates Microsoft-standard .OBJ modules. It supports five different 8086 memory models: small, compact, medium, big, and large; no other implementation reviewed supports more than one. Also, it is the only Pascal reviewed that is capable of generating 80186/286- and V20/V30-specific opcodes.

As with MS Pascal, 8087 support is handled two ways: by generating in-line 8087 code or by generating calls to a library that either uses the 8087 if present or emulates it if not. The in-line code is faster, and the timings in table 2 reflect that configuration.

The system is shipped on seven diskettes. It cannot be used on a floppy-disk-based system, because the compiler program is a single .EXE file 638KB in size. Obviously, overlays have been bundled into the root program for simplicity's sake. A superb installation program reads portions of large files from multiple diskettes and reconstructs the files on the target hard disk. It also builds subdirectories for all requested memory models and puts every one of the close to 80 files where it belongs.

The system borrows concepts from both C and Ada. A very C-like macro preprocessor is included, as is C-style pointer arithmetic. From Ada comes the *pragma* jargon for compiler commands and the extraordinarily sophisticated separate compilation scheme called *packages*. Ada-style comments are supported, for which a double dash (--) begins a comment that ends with the end-of-line character.

Compile speed is slower than that of MS Pascal, and the speed differential increases with the length of the program. The compiler posts more information to the screen as it works than any other compiler. The compiler warns of loose-end conditions, such as variables declared but not used, parameters passed but not used, and variables initialized but never referenced. These can be useful reminders of procedure stubs in need of completion, leftovers from a program redesign, and so on.

The speed of produced code, on the other hand, runs from good to spectacular. It has the fastest file access times of any compiler reviewed, in all categories, and can write 1,000 binary records to disk in less than four seconds. In Sieve performance it comes in slightly ahead of Turbo Pascal and slightly behind MS Pascal—although in practical terms, it is a three-way tie. Only in heap management are Professional Pascal's timings disappointing.

Table 2 has two columns for Professional Pascal—one for small and one for large models. For comparison to MS Pascal use the large model column. The speed advantage of using the small model is slight at best, except in terms of heap speed—and a short heap is only a marginally useful creature. Note that the .EXE file sizes for Professional and MS Pascal are so close as to be essentially identical.

A rich suite of numeric types is available. All three IEEE real formats are supported: 32-, 64-, and 80-bit reals. Unsigned integers are provided as type Cardinal. Four-byte long integers are available, with a range identical to MS Pascal's Integer4. Professional Pascal has no predefined Byte type, but the compiler can optimize an integer subrange of 0..255 into a single byte of storage. The documentation is honest enough to mention that multiplying two long integers cannot be done in 8086 registers and thus is much slower than similar operations on integers or cardinals.

Variable-length string support only roughly resembles that of the other compilers. String types have a two-byte leading length specifier and may be 65,534 characters long. A package of string manipulation routines allows all standard UCSD string operations, but routine names and syntax are different.

One aspect of file support is the only serious drawback of Professional Pascal. In their very serious concern for portability, its authors have refused to

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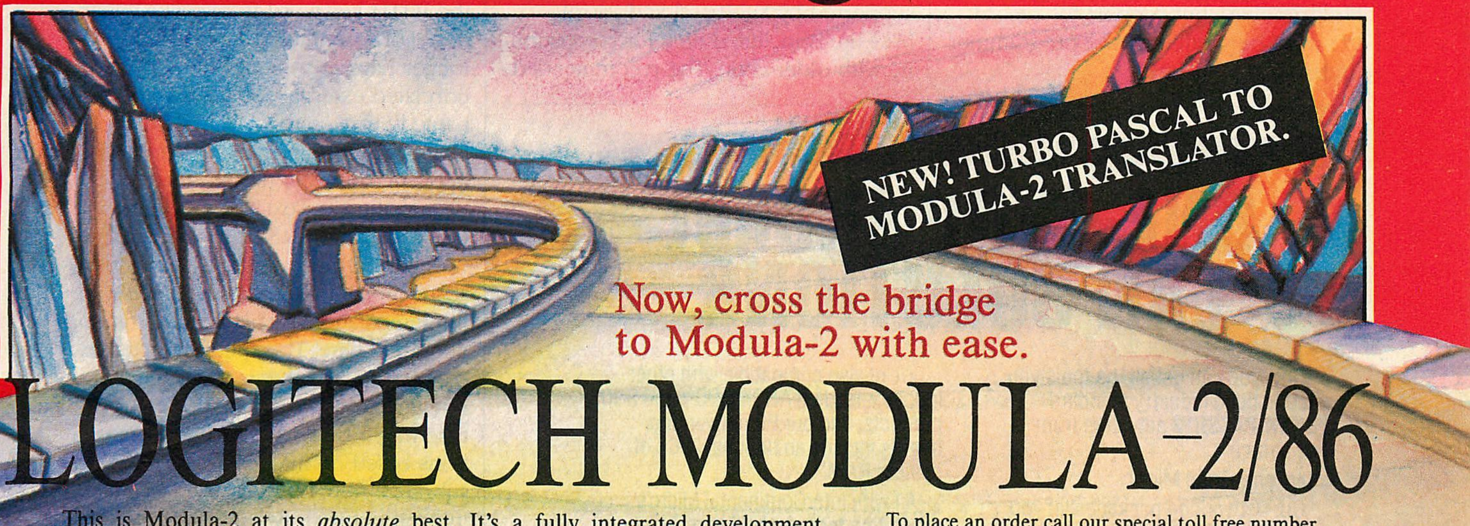

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extend the standard by allowing an update mode for file access using standard file notation. In other words, Reset opens a file as read-only; a record read cannot be updated and rewritten to its previous position in the file. This is an essential operation in business programming, and all the other Pascals reviewed here include it. Update mode is supported when using a supplied library of character-oriented C-like file primitives, but support for record I/O must be written by the programmer under such a system.

Otherwise, file support is good, and file performance is unexcelled. Seek supports random file I/O. Close works as in the other Pascal implementations. File status is returned by a library package routine.

Professional Pascal's provisions for separate compilation are the most detailed and powerful of any Pascal reviewed. Its traditional external declaration scheme, which is similar to that supported by MS Pascal and Pascal/MT+86, is included only for compatibility with older code. The recommended method is to form packages similar to those defined for the Ada language.

A package is much like MS and UCSD Pascal's unit. It has an interface-and-implementation part and allows internal details of exported objects to be completely hidden from the importer. Additionally, packages allow two imported objects to have the same name by specifying the object name after its package name, using *dotting* or the WITH key word from record notation. For example, programmers no longer have to worry about using two unrelated external routines, both named Strip—one to strip white space from text lines and one to strip file headers from data files; instead, one can be specified as TextTools.Strip and the other as FileTools.Strip.

Furthermore, packages allow data abstraction—that is, hiding a type's implementation details from the importers of the type. The simplest example concerns a type that is a subrange of Integer: programmers importing the type might be tempted to make assumptions based on integer properties; the subrange might be imported as a closed interval between two constants whose values are also hidden, allowing some limited work to be done with the subrange without revealing its base type. Professional Pascal also provides manual and automatic aliasing of objects with identical names in different packages across linkable boundaries, because linkers do not understand packages and cannot deal with two objects sharing the same name. Such techniques have been used in certain mainframe languages for some time.

Professional Pascal's documentation is certainly the best of any compiler reviewed here. Like the others, it is divided into two volumes: a programmer's reference, which deals with compiler operation and implementation specifics, and a language extension manual, describing Professional Pascal's extensions to standard Pascal. The documentation does not describe standard features except to contrast them with language extensions. Each extension is given a very complete description as well as a rationale describing what the extension is for and why it is included. The descriptions are wonderfully complete and concise. None of the vagueness that mars documentation for MS and UCSD Pascal is apparent. The 20-page tutorial on packages, for example, is a model of technical clarity.

The indexes for the two volumes are quite unusual; key words are indexed along with a few words of con-

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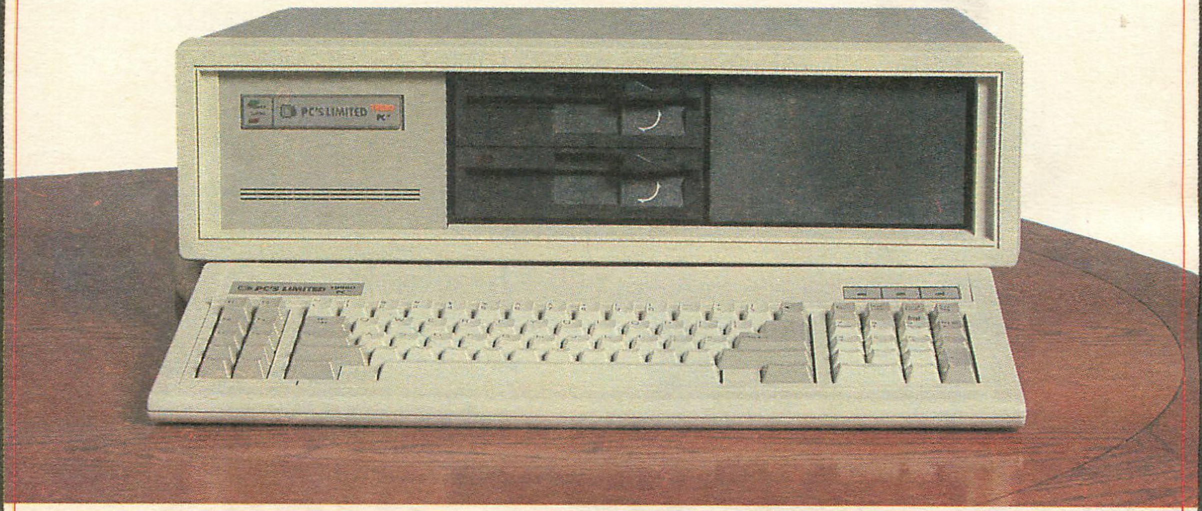

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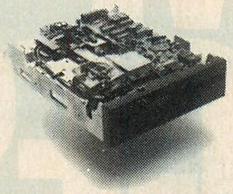

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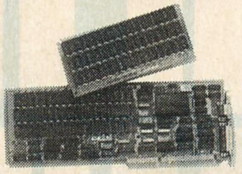

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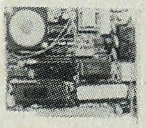

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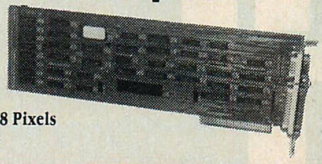

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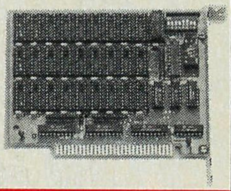

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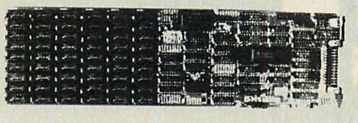

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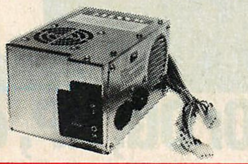

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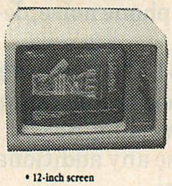

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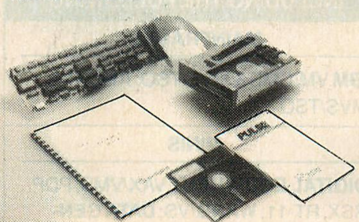

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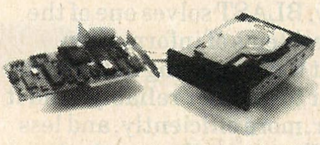

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text to clarify their meaning, with the key words themselves lined up in a single column in the center of the page. This creates an index that can be easily scanned. A full page of instructions on how to use the index is included. Furthermore, the indexes are large—21 full pages of single-spaced type for the programmer's reference.

Both compiler and generated code are robust. One peculiar bug was identified, however: the compiler chokes on a small number (about 40) of comment delimiters (curly braces or asterisks) in column 1 of the source file. Aside from the fact that Pascal is supposedly column-independent, every considerable Pascal system I have seen has hundreds of comment delimiters in column 1. The interface library source code provided with the product uses the Ada-style double-dash, rest-of-line comment delimiter almost exclusively, so this bug may be an oversight based on a developer's stylistic preferences. It shakes the user's confidence in the rest of the system, however. That, and the inability of the code to open a file of records for update are the only serious flaws in an otherwise rock-solid product.

Professional Pascal makes no concession whatsoever to simplicity. The aim is power, and power is what it delivers, damn the cost. This is at once the most expensive, best documented, most powerful, and least accessible Pascal available. It requires a great deal of study and close attention to its mountain of detail, but it is capable of handling as large and complex a project as anyone would ever be willing to undertake in Pascal.

TURBO PASCAL

A certain elemental tension exists between ease-of-use and complexity in the nature of any tool. Very powerful tools tend to be complex and require much study and practice, losing the beginner and the impatient in the process; tools with little power are branded as toys and quickly shelved. Somewhere between the two is a "Golden Mean," at which a tool can be simple enough to draw in the new and the restless, yet powerful enough to accomplish significant work. Turbo Pascal has struck closer to this ideal than any compiler reviewed; this more than anything else accounts for its incredible popularity. (Turbo Pascal was *PC Tech Journal*'s Product of the Month in January 1985.)

Turbo Pascal is a programming environment, the same as Mystic and UCSD Pascal. Within the environment are a text editor screen and two menu screens. Text editing is done in the editor, and all other tasks are done from the menus. The menus are of the traditional press-a-character-to-choose type rather than pull-down or pop-up.

The system is very compact—a single .COM file of about 40KB. All parts of the system reside in RAM at once, so no time is lost loading system utilities or overlays. Moving among the menus and the editor is usually accomplished with a single keystroke (except to leave the editor, which requires two) as are virtually all system commands.

Compilation is accomplished in one pass to native code, which can be directed to storage in RAM (for greatest speed) or to disk as a stand-alone .COM executable file. No link step is necessary; the output from the compiler is executable code. When compiling short programs to RAM, compile time is usually only a few seconds on a PC, and even less on an AT. The environment serves productivity well and is never so obtrusive as to break a critical train of thought while developing code. As with UCSD Pascal, however, errors can be

detected only one at a time, which often makes the task of importing code from another not-quite-compatible compiler tedious in the extreme.

Borland's compiler breaks down into three separate products by the nature of floating-point support: Turbo Pascal, Turbo-87 Pascal, and Turbo-BCD Pascal. Each is a distinct and separately priced version of the environment, configured for a different real number format. The standard Turbo Pascal uses a proprietary six-byte real number format providing 11 significant figures and a range of 10^{-38} to 10^{38}. It cannot make use of the 8087 coprocessor. Turbo-87 uses the IEEE double-precision real number format occupying eight bytes and providing a range of $4.19 * 10^{-307}$ to $1.67 * 10^{308}$. Code generated by Turbo-87 Pascal always uses the 8087 for real number operations and cannot be used on, nor can generated programs be run on, a machine without an 8087 or 80287. BCD support is provided by Turbo-BCD Pascal, which lacks a floating-point real type as well as certain built-in functions that make sense only in a floating-point context, such as Sin, Cos, ArcTan, Ln, Exp, and Sqrt. It operates with 18 significant digits, including four fixed decimal places.

The Turbo Pascal editor is a full-screen text editor, the command set of which is a subset of WordStar's, with a few annoying peculiarities. For example, tab characters in imported text are displayed as highlighted *I* characters (tab is Ctrl-I), while tabbing within the editor does not insert tab characters but instead puts spaces in the file until the cursor rests under the start of the next word in the previous line. The editor is not function-key driven, but a keyboard macro such as SuperKey can make the Turbo Editor "look" more like another editor if desired. Simple key-definition changes also can be made with a supplied installation utility.

The Turbo Pascal editor can pinpoint a compile-time error in the source code, allowing the programmer to enter the editor at or near the probable cause of the error in source. The Turbo Pascal system also uses this feature to locate the position of runtime errors located in the source file, by recompiling code until the number of bytes of generated code equals the program counter value displayed when the runtime error occurred.

Typically, a Turbo Pascal program allocates all available free RAM to the heap, once it has set aside room for the code and data segments. The secondary menu allows code, data, and heap sizes to be adjusted for programs compiled to .COM files. This is required by Turbo's program chaining scheme, which requires that enough code and data space be allocated in the root program to contain the largest program file to which control will be passed.

No linkable object format is available from Turbo, but a mechanism exists to declare a machine-code routine as external and read it from disk into the code segment at compile time.

Turbo supports the standard Pascal integer and an unsigned Byte type ranging from 0 to 255. It has no unsigned integer type (such as Word in MS Pascal), nor any long integer type. Lack of these two numeric types forces the use of real numbers in counting common system resources such as disk sectors, file records in large files, and available paragraphs of heap space. Counting with real numbers grits like sand in the teeth; this deficiency detracts from Turbo's best application: the building of small to medium-sized utilities.

Long heap support uses New and Dispose, along with MemAvail and MaxAvail. (Mark and Release also are available for atavists.) Its 32-bit pointers can address all available RAM. Considering that it is a long heap, Turbo Pascal's heap support is very fast, more than twice as fast as Professional Pascal's short heap support in its small memory model. Entire text or graphics screen buffers can be stored on the heap and flashed into the video refresh buffer with the built-in Move statement.

String support is UCSD-style, an array of characters with a leading length byte. UCSD-style string primitives are built in, including Concat, Insert, Delete, Copy, Length, and Pos. Additionally, the plus symbol functions as a string concatenation operator. The complementary routines Val and Str perform numeric/string conversions.

Turbo provides an excellent suite of low-level machine hooks for DOS compatibles. Intr and MSDOS support software interrupt and DOS calls. All of memory is available through two predeclared arrays: Mem, which treats memory as an array of Byte, and Memw, which treats it as an array of Integer. These arrays may be handled exactly as though they were user-defined, save that the array as a whole may not be referenced. Similarly, two arrays, Port and Portw, allow read and write access to all 8086 I/O ports. Turbo Pascal shares its Move, FillChar, and Sizeof routines with UCSD Pascal.

On a higher level, simple text and graphics windowing routines, CRT

mode controls, and raster and turtle graphics primitives are all provided. The graphics primitives are available as an external machine code file; all other features are built into the compiler itself. The graphics routines are not very fast and limited in many ways. The Circle routine, for example, cannot compensate for the IBM Color Graphics Adapter's asymmetrical pixels, and it produces pronounced ellipses in both of the graphics modes.

Portability is up to the programmer but is made easier by Turbo's fairly high degree of vertical portability to UCSD, Utah, and Pascal/MT+86. (UCSD is older than and served as a model for those three newer Pascals.) Aside from reasonable compatibility with UCSD Pascal, horizontal portability is limited to CP/M-80 and CP/M-86. Developers must keep in mind that a good many of Turbo's extensions, including text windowing and graphics, are limited to the DOS implementation. Turbo Pascal for the Macintosh and Amiga have been announced but not yet delivered.

Turbo Pascal's downward deviations from standard Pascal are fairly few, but two in particular are very irritating. Get and Put are not available; both text and binary file I/O are accomplished through Read and Write. Although Borland's extension of Read and Write are rational and intuitive, the change makes converting file-intensive code from another compiler far more work than it should be. Turbo Pascal also limits the use of Goto to within the current block. The rare times that a Goto is called for, typically in emergency situations when a program must cease what it is doing and do something else *now*, are not satisfied under Turbo's limitation. Page is not supported and is flagged as an error, but could easily be ignored. Packed is allowed, but is not functional. Procedural parameters are not supported, and variant records may not be allocated on the heap via New.

Turbo Pascal's documentation is a 375-page paperback book. It has too few useful examples of Turbo Pascal's more arcane features. In contrast, its index is excellent and its table of contents is good enough to be used as a second index. The simplicity of Turbo Pascal helps here. Its documentation is fairly complete without being as thick as a phone book. Although the font and general design are very legible, typographical errors have been a problem since release 1.0, and the first pass should be made with a red pen and the READ.ME file close at hand.

Support is available not only from Borland itself but from many user group SIGs and a forest of computer bulletin boards. Megabytes of public domain source code are available from user groups and BBSs, and while some of it is predictably amateurish, much of it, like the PIB utilities from Northwestern University's Phil Burns, is excellent. Turbo's third-party enhancements have exploded over the last 12 months and now comprise an industry to themselves. Bizarre but useful solutions to Turbo's lack of a linkable object format have been offered, along with many excellent source-form and external-form libraries from vendors such as Blaise Computing and Metagraphics. Several good books focusing exclusively on Turbo are available, and Borland itself publishes a detailed beginner's tutorial, called *Turbo Tutor*.

Against all of this must be weighed the 5,000-line barrier: for applications longer than 5,000 lines, Turbo Pascal becomes considerably more trouble than a compiler designed specifically for large projects, such as MS Pascal and especially, Professional Pascal. Overlays can extend the 64KB code segment limitation considerably, but Turbo Pascal overlays make an application notoriously difficult to debug. Lack of an .OBJ format makes symbolic debugging techniques useless. Without any convenient means to break down a large application into separately compiled boxes, Turbo is not particularly appropriate for team-developed software.

On the other hand, Borland President Philippe Kahn has made it plain that these are design decisions serving an overall goal of simplicity. Within its niche, for utilities and business applications up to about 5,000 lines in size, Turbo Pascal is unexcelled.

UCSD PASCAL

When SoftTech Microsystems went bankrupt last year, a group of investors and long-time p-System users purchased the company's assets and re-released the p-System and the three UCSD languages, Pascal, FORTRAN, and BASIC, under the name Pecan Software Systems. The p-System and one language can be purchased for $79.95—an awesome bargain for a system of this power. More languages are under development, including C and COBOL. Pecan recently bought Volition Systems and will be adding Volition's p-System-based Modula-2 compiler to the Pecan line. The new company's stated intent is to have every major language implemented as quickly as possible.

The driving force behind the p-System philosophy is horizontal portability. The p-System is actually an operating system atop an operating system and provides a common face to the programmer no matter what operating system lies beneath it. It is available for virtually all important machines and operating systems (see table 1).

The p-System reflects 1977 thinking in many ways. Disk storage is handled by defining virtual volumes on the host system disks. A virtual volume can occupy an entire floppy disk with a proprietary format, or it can be a large DOS file on a floppy or hard disk. Unlike DOS, the p-System has no FAT, and disk sectors are allocated statically. If several files are created sequentially on a volume and a few are deleted in the middle, the space they took is not returned to a free sector pool; instead, it remains as "holes" in the volume. To consolidate and reclaim the space, a "Krunch" command must be issued explicitly, which moves files around wholesale until all free space is collected at the end of the volume.

Differences in instruction sets and architectures are handled by creating a pseudomachine (p-machine) that has its own pseudoinstruction set that is the same across all p-System implementa-

tions. This p-machine is an interpreter and exacts a perceptible but not unacceptable overhead. (There are mitigating factors for the PC; see below.) The system components are written in the p-machine's p-code, so to move the system to a new environment, only the interpreter must be rewritten.

Languages under the p-System all compile to the same p-code and follow identical calling conventions, so modules separately compiled under Pascal, BASIC, and FORTRAN (as well as upcoming new languages) can be linked interchangeably, as is possible with Microsoft's Pascal, C, and FORTRAN.

The p-System is menu-driven, with each menu a line of key words displayed at the top of the screen. Each key word may be selected by a single character. The major system components are the editor, compiler, and filer. Optional components include debugging tools and a p-assembler for creating p-code directly. As with Turbo Pascal, the programmer enters a working file name and then can move freely between editing, compiling, and running the program under development.

The UCSD compiler operates in a single pass to p-code. Some implementations, including the PC's, have a native code generator that may be invoked as a second pass. Even though native code may be produced, the files cannot stand alone; many of the built-in functions remain in p-code libraries. Nor can the interpreter and libraries be combined into a stand-alone DOS file; however, the p-System may be configured to "autostart" an application as soon as the p-System is invoked from DOS.

The native code generator pass is unique in that it can be invoked on a procedure-by-procedure basis. Integer performance improves by a factor of eight for native code over p-code, and by a factor of three for nontranscendental real operations. Native code does little for heap, screen, and file operations, so such code is best kept in the more compact p-code form.

Compiler performance falls somewhere between the disk-bound filter-type compilers of MS and Professional Pascal and the memory-resident Turbo Pascal. The compiler must be loaded from disk each time it is invoked, but the source code remains in RAM for small files. Object code is always written to a disk file. Given all that disk access, the compiler is fast, but it is slow enough to start a programmer's toe tapping, even on small projects.

Code performance holds some surprises. On the screen access benchmark, UCSD Pascal beat all other products except Mystic Pascal by at least a factor of three, even from p-code. The native code generator is good and puts UCSD numerics in the same league with Turbo, MS, and Professional. Where the intervening layers of the p-System make themselves felt most strongly is in file I/O. UCSD file performance lags behind Turbo, MS, and Professional by an order of magnitude.

The UCSD editor can best be described as an obtrusive nuisance and is by far the weakest part of an otherwise strong system. It dates back to the genesis of CRT terminals and is designed to minimize the influence of slow serial terminal links and limited CRT control. In recent years editing software has moved away from strictly delimited modes to unlimited full-screen insertion and deletion, but the UCSD editor's four major modes—insert, exchange, delete, adjust—remain.

In the editor's command mode, the cursor can be moved about the file, but only commands may be entered; nothing can be typed or deleted. To delete

text, the user must enter D, move the cursor past the text to be deleted, and then press Ctrl-C. Any text between the cursor's position on entry and exit from delete mode is deleted. Insert mode inserts text, and exchange mode types over existing text. Each mode must be exited by pressing Ctrl-C, at which time changes made take effect in the file. Control of Pascal's line indentation on existing text must be handled from adjust mode, which allows a line to be moved horizontally.

Performing any amount of editing using these modes takes two or three times the keystrokes a more modern editor requires. Fortunately, the UCSD editor is an installable program file (unlike, say, the Turbo Pascal editor) and if the p-System becomes popular again, someone could make a lot of money offering a p-System text editor that operates like the Turbo editor or Satellite Software International's P-Edit.

UCSD Pascal supports the standard Pascal integer and expresses real values in eight bytes. It has no unsigned integer or byte types. However, an intriguing variable-precision long integer type may contain up to 36 significant digits. The long integer is not a simple type and is not able to be returned by a function, act as a loop control variable, or index arrays. The limitations of the long integer type are not fully explained in the text and had to be discovered by experimentation.

Support of the 8087 is handled by installing a special version of the p-machine interpreter, the runtime library, and the native code generator. The 8087 native code generator produces a six- to eightfold improvement over p-code in real number and transcendental performance.

If UCSD Pascal's file support looks familiar, it may be because later and more familiar implementations such as Turbo and Pascal/MT+86 use it as a functional model. Seek and the IOResult function originated here. No Assign procedure is available; logical/physical file assignment is handled within Reset and Rewrite. Ordinarily, files are handled through the p-System's file manager, but if broad horizontal portability is not an overriding concern, a feature called the *DOS bridge* allows direct access to DOS files. This improves performance somewhat over p-System access (except, inexplicably, for text file reads), but sacrifices the portability that is the p-System's greatest virtue.

UCSD string support is similar to Turbo Pascal's, because UCSD set a consistent standard for Pascal strings that Turbo followed. String variables are represented identically, as arrays of characters with a leading length byte; UCSD was the basis for all of Turbo's string primitives, except Val and the plus symbol for string concatenation.

Separate compilation is similar to MS Pascal's scheme. A separately compiled unit has both an interface and an implementation part, and, once perfected, compiled units may be gathered into libraries with an included utility. Units can serve as an overlay scheme—a unit generates a p-System code segment and may be swapped in and out of memory by the runtime memory manager. The p-System's "real" overlay scheme—called *segmentation*—is more appropriate for dividing large programs into manageable sections.

Not much in the line of debugging tools is provided with the $79.95 package. This is an important consideration, because most DOS-based debuggers will not work under the p-System. A separate $49.95 package contains a symbolic debugger, p-instruction disassembler, cross referencer, and toolkit for recovering data from damaged disks.

A host of library units provide frosting to the basic Pascal toolkit, including text windowing, turtle graphics, IBM display adapter low-level support, joystick, paddle, light pen, and sound support, keyboard redefinition, and system clock access. A serial communications utility is included with every implementation of UCSD Pascal to facilitate wire transfer of files between machines with incompatible media. Pecan's turtle graphics are fast and have elements of raster graphics often missing from turtle implementations. This is certainly appropriate for generating business graphics, although no graphics printer support is provided.

Like Mystic Pascal, UCSD supports concurrent processes—but UCSD's are fully implemented. To call concurrent processes multitasking is stretching the point, because no time slicing is involved. A process, once it is initiated, continues running until it is interrupted or finishes or must wait on a semaphore. Hardware interrupts and two higher-level events may suspend a process in favor of another: the PC's timer tick and a key press. Using these events and semaphores, a programmer could build a time-slice emulator in Pascal, but the overhead exacted probably would be unacceptably large. Processes are much more suitable for problems such as communications input buffering and keyboard input editing. Pecan's documentation of concurrency is insuf-

ficient—a person unfamiliar with the concept would be lost.

It is too early to judge how well Pecan will support the reborn p-System—the acid test will come when 100,000 or more units are sold and in use. The documentation will help, as it is enormous (593 pages), dense (each page is filled to the brim), and reasonably complete. Such a large tome is necessary because the p-System is complex and for most DOS users is an alien environment. A very good tutorial begins the manual and quickly gives the new user a flavor for the system in general and the editor in particular.

The manual suffers from the same disease as MS Pascal's—essential details are missing, typically in the most technical areas. One example is the lack of detail regarding variable-precision long integers, as mentioned above. Another involves concurrency; the statement is made that a process's stack must have room to evaluate expressions, but no guidelines are given on determining how much room is required. Documentation on concurrency is almost nonexistent—this is made all the worse because it is a unique and potentially valuable feature that probably goes unused for being so badly understood.

UCSD Pascal's fundamental problem is that it must drag its past along with it. Clever work could free it to some degree; the p-System could be modified to do dynamic sector allocation in the DOS fashion, rather than the older delete-and-repack model of disk management. Its editor could be replaced tomorrow with something better. These anachronisms, along with its isolation from DOS, might warn some developers away.

UCSD Pascal is, however, a special case, because the overhead of the p-System buys what no other Pascal can hope to offer: near-absolute horizontal portability to virtually every microcomputer and operating system of consequence in use today. Every copy of an application requires a copy of the environment, but various licensing arrangements are available for developers that can bring the per-copy overhead well below the $79.95 list price.

UCSD is not a good choice for developing small utilities, because all applications must be run from the environment. Nor is it likely to compete for developers who limit their scope to IBM PCs and compatibles, where runtime fees for developer tools have all but disappeared. For the vertical market applications developer chasing a narrow niche, however, this is the only choice.

MYSTIC PASCAL

Mystic Pascal is the latest product from James R. Tyson, who wrote JRT Pascal for CP/M-80, and Utah Pascal, which is JRT Pascal converted to DOS. At the time of this review, Mystic Pascal was incomplete, lacking many features of standard Pascal and even some described in its own documentation. However, the product was on the market and met the other criteria, so it is included here. Mystic Canyon Software's target date for full support of the ISO standard was June 1.

Mystic Pascal is a programming environment with a very elegant function-key-driven design. The programmer may move between four screens, each with a distinct function: (1) text editor; (2) direct mode for executing programs and procedures and displaying the values of variables; (3) a system display that gives the current extent of stack, heap, data area, and other environment parameters, including a display of the status of concurrently executing processes; and (4) the laser display, which is not explained in the documentation but is a hex dump of the region of RAM containing the program code and data. Moving between the four screens is accomplished by a pop-up menu invoked by the F1 key. Executing system commands is done from a menu invoked by F2. Keys F7 through F10 display help screens summarizing the Pascal language and editor commands.

The compiler makes two passes to native code. The first pass creates an optimized intermediate code, which is then immediately converted to native code and stored in what is called the *laser area*. This area also stores the heap and the tokenized source file currently being edited. The laser area allocates as much RAM for itself as it needs, and it can expand to occupy all available RAM. This is fortunate, considering that all source and object code must reside in memory at one time, and neither separate compilation nor source include files is supported. An .EXE file generator for stand-alone program modules is planned but was not yet implemented at review time. Currently, code must be developed and run from within the environment.

The system compiles extraordinarily quickly, mostly because it is an incremental compiler—that is, it compiles just those portions of the source that have changed since the last compile. Only when a source file is loaded initially from disk is the entire file compiled at one time. Also, a partial compilation of a source code line happens

each time a change is made to the line and the cursor leaves the line. These line-by-line incremental compilations are so rapid that the programmer does not notice them. Because of the speedy compilation and the instantaneous transfer from one screen to another, the system is very interactive and development can move extremely quickly once the shape of the system sinks into the user's reflexes.

The missing entries under Mystic in the benchmark timings table bear explanation. The linked list timings could not be taken because implementation of pointers was not complete at the time of the review. The text file read test was not implemented because Mystic Pascal cannot read a line from a text file as a unit into an array of characters via Readln. This is in line with standard Pascal, but the alternative, reading a line one character at a time by looping and testing Eoln, is so much slower than line-by-line text file I/O that comparing the two techniques would be unfair. Every other Pascal tested supports line-by-line text file I/O into string types or character arrays. Note that the screen I/O benchmark took place in nine seconds—one-third the time of UCSD Pascal and an order of magnitude faster than any other compiler.

Compiler reliability is poor. Mystic Pascal frequently locks up the AT or aborts to the DOS command line without warning. Mystic Canyon indicated that it has never systematically tested the product on the AT. On both the PC and AT, the compiler enforces its capitalization conventions on reserved words embedded in comments. Programs without reserved words in comments seem to compile and run more reliably, especially when multiline comments are involved; the line-oriented precompiler tokenizes comments but marks the tokens as nonexecutable. Single quotes within a comment confuse the system and often cause it to crash.

Incomplete as it is, Mystic Pascal is a remarkable product in several ways. It is the first incremental Pascal compiler of which I am aware, and it is also the first to incorporate multitasking in the compiler mechanism itself. The manual describes elaborate support for coprocesses, although not all of that support was implemented at the time of this review. At $16 for a version with the documentation on disk, it is the least expensive vendor-supported Pascal in history. Printed documentation adds another $16 to the cost.

Mystic Pascal is not ready for serious software development at this time, but it has some intriguing technology lurking inside. Once its support for concurrency and the ISO standard is fully implemented, it will be worth its price simply to experiment with coprocesses on a high-level language basis.

UTAH PASCAL

When Jim Tyson released his JRT Pascal for CP/M-80 in 1982, the Pascal world went wild. It cost $29.95, far less than any other commercial Pascal compiler. More than 100,000 orders came in, swamping Tyson's one-man operation and getting him in trouble with the Federal Trade Commission for failure to ship merchandise. JRT Pascal is still available from Ellis Computing as Nevada Pascal; Utah Pascal is JRT processed through Digital Research's 8080/8086 source code conversion utility and touched up to support DOS.

Utah Pascal is a filter-type compiler that processes source code to intermediate code, which is then executed by an interpreter program. The runtime interpreter cannot be merged with the intermediate code to produce a single stand-alone program. No native code generator is available, nor is any use made of the 8087. As might be expected, Utah Pascal produces the slowest code of any compiler tested.

The Utah compiler is fairly slow and locked up the computer several times during attempts to compile code from other Pascal dialects that did not match Utah syntax in all respects. A good compiler should display a meaningful error message and exit to the operating system without locking up the machine, regardless of how confused the system might be. This tendency to lock up and glacially slow code execution are Utah Pascal's worst faults.

Separate compilation is supported by a virtual storage manager acting as a smart overlay system that loads separately compiled external code modules as needed, keeping track of what has been loaded into memory and how much RAM remains. A queue of loaded routines is kept, and when storage gets short, the oldest routines are disposed of as though they were dynamic variables, until sufficient space is reclaimed.

Optionally, the programmer may link separately compiled modules with the compiled main program to produce a single intermediate code file that loads as a unit. Only 64KB are allowed for program code (excluding the runtime interpreter), stack, and heap; thus, linking modules into a single large main program decreases available stack and heap space. By leaving separately

compiled modules on disk, a program's size is limited only by disk space, thus leaving management of the 64KB segment to the virtual storage manager. The penalty is disk access time and the possibility that bad program design could lead to disk thrashing.

Utah Pascal supports a single real number format with 14 significant digits and a range of 10^{-64} to 10^{63}. All transcendental functions (Sqrt, Sin, Cos, Arctan, Ln, and Exp) are provided in Pascal source form only. They must be compiled to intermediate code and then interpreted as externals. Evaluating the expression Sqrt(Sin(Ln(3.14159))) 10,000 times takes 14,248 seconds, or 1.4 seconds for *each* evaluation. The source code for the transcendental functions is uncommented and not much can be learned from it. No way is provided to link machine code routines to the runtime interpreter.

Only a short heap (16-bit pointers) is available, and it must share a single 64KB segment with intermediate code, program data, and stack. Utah Pascal therefore does not make use of RAM much beyond the 128KB point. The heap is managed by the New and Dispose commands, but MemAvail and Maxavail are not implemented.

Utah Pascal's downward deviations from standard Pascal are fairly few. Most are in file syntax. Read/Write and Readln/Writeln syntax has been altered in a confusing fashion. Random file access is accomplished with a needlessly complex variant on Read and Write rather than Seek. The standard predefined type Text is not supported; text files must be declared as FILE OF Char.

Utah Pascal has a good deal in common with Turbo Pascal. Its string handling is very similar, including string primitives Concat, Copy, Delete, Insert, Length, and Pos. An interesting BASIC-style dynamic array type is available. Dynamic arrays can be redimensioned during program execution to arbitrary dimensions not known at compile time and disposed of completely when they are no longer required. One very nice extension is a Picture function that formats real numbers to a COBOL-style PICTURE specifier, similar to Form in Turbo-BCD Pascal.

Few low-level system hooks are provided. Port I/O is supported, and a pointer can be generated to any address within the program's 64KB segment using a Map function—but it cannot point to CRT buffers and BIOS data areas outside the data segment. A CP/M-style DOS call routine (which makes a short jump to offset 5 in the code segment) is provided, but no way is given to call arbitrary software interrupts.

Utah Pascal's interpreter can be toggled into and out of line trace mode, similar to TRON and TROFF in IBM BASIC. Also available is a procedure name trace mode that prints out the name of any subprogram when that subprogram is called. The runtime interpreter displays a very useful postmortem dump of system status values (including stack base, top of stack, bottom of heap, and intermediate code address) when a runtime error occurs.

The only coding bug discovered during testing is that write parameters in Write and Writeln statements (that is, Write(I : 4);) do not right-justify data values in the specified field width. The documentation is only minimally adequate; it consists of a 132-page, perfect-bound volume with few useful examples and at least one major error in the description of the Call procedure: the order of the register-load variables was given in reverse, causing unpredictable mayhem during attempts to perform different DOS calls.

Aside from providing an upgrade path to DOS from JRT or Nevada Pascal for CP/M-80, Utah Pascal does not have much to recommend it. With its design philosophy firmly rooted in the eight-bit world of 1981, this is a product whose time has long passed. It wastes the resources of the PC by ignoring most of the available RAM and by swallowing machine cycles in a ponderously slow runtime interpreter. Utah Pascal's virtual storage manager, clever as it is, is a solution for a problem that no longer exists, now that 64KB of RAM costs $10. While the code produced seems adequately robust, the compiler crashes unpredictably when too many semantic errors are encountered.

HITTING STRIDE

The very first Pascal compilers were packaged in plastic bags. They lacked reals, records, and had no documentation to speak of. Second generation Pascal compilers such as Pascal/MT+ implemented a spottily extended standard Pascal, but came with plenty of bugs, torpid code speed, and documentation that was at best tolerable. This was the status quo two years ago.

The third generation is now with us. Current Pascal compilers not only are acceptably bug-free and incorporate highly intelligent optimization, but they also have begun to specialize by application and market segment.

MS Pascal and Professional Pascal are peers in a similar market, and

choosing a clear favorite is difficult. Professional Pascal costs almost three times more than MS Pascal, yet does not seem to provide three times the value. Much of Professional's added worth lies with features a casual programmer will probably not even understand, much less use. By being simpler and easier to understand and use, MS Pascal is a better value for the vast majority of medium to large applications written by a single programmer. But for team programming or for very large projects comprising dozens of independently developed modules, Professional Pascal stands absolutely alone.

IBM Pascal is a slightly simplified earlier version of MS Pascal with inferior documentation and a higher price tag. Turbo Pascal has yielded the high end of the market to achieve a speed and elegance that the larger compilers cannot match. UCSD Pascal competes best when narrowly directed toward applications that demand broad horizontal portability, but it succeeds to a degree impossible with the other compilers. As for Utah and Mystic Pascal, one's time has passed and the other's, perhaps, has not yet arrived.

The drawing together of the true native code compilers in the performance table suggests that the Pascal compiler art for the 8086 is reaching an optimum state. Pascal's safeguards exact a certain performance penalty—for greater speed, assembly language or C is the answer. Pascal, however, was not designed for code speed, but to facilitate supportable, structured program design. From that perspective, the state of Pascal is quite clear: the language has hit its stride.

IBM Pascal: $385
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Microsoft Pascal: $300
Microsoft Corporation
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Redmond, WA 98052-6399
800/426-9400; 206/882-8080
CIRCLE 352 ON READER SERVICE CARD

Mystic Pascal: $32
Mystic Canyon Software
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Pecos, NM 87552
505/757-6344
CIRCLE 353 ON READER SERVICE CARD

Professional Pascal: $695
Microtec Research
P.O. Box 60337
Sunnyvale, CA 94088
408/733-2919
CIRCLE 354 ON READER SERVICE CARD

Turbo Pascal: $69.95
Borland International
4585 Scotts Valley Drive
Scotts Valley, CA 95066
408/438-8400
CIRCLE 355 ON READER SERVICE CARD

UCSD Pascal
Pecan Software Systems
1410 39th Street
Brooklyn, NY 11218
800/63-PECAN; in New York, 800/45-PECAN
CIRCLE 356 ON READER SERVICE CARD

Utah Pascal
Ellis Computing, Inc.
5655 Riggings Court, Suite 10
Reno, NV 89502
702/827-3030
CIRCLE 357 ON READER SERVICE CARD

LISTING 1: BENCHER.PAS

```
{$floatcalls-}
{$real:8}
PROGRAM Bencher(INPUT,OUTPUT); { For MS Pascal }

CONST
  Size     = 8190;

TYPE
  String64 = PACKED ARRAY[1..64] OF CHAR;
  NodePtr  = ^Node;
  Node     = RECORD
               X,Y : Integer;
               Next : NodePtr
             END;
  DataRec  = RECORD
               CustNum  : Real;
               CustName : String64;
               Current  : Boolean
             END;

VAR
  NCount          : Integer;
  Root,Current    : NodePtr;
  TestNode        : Node;
  I,J,K           : Integer;
  R,S             : Real;
  TextLine        : String64;
  TextFile        : Text;
  ReadText        : String(64);
  CustRec,NewRec  : DataRec;
  CustFile        : File of DataRec;
  O               : Text;

FUNCTION TICS : WORD; EXTERN;
PROCEDURE TIME(VAR S : STRING); EXTERN;

PROCEDURE Show_Time(VAR OutFile : Text);

VAR
  TimeString : LSTRING(15);

BEGIN
  TimeString := '          ';
  Time(TimeString);
  Writeln(OutFile,TimeString,'.',Tics:2);
END;

FUNCTION NullFunction : Integer;

BEGIN
  NullFunction := 0;
END;
PROCEDURE TestProc(K : Integer;
                   CH : Char;
                   MyPtr  : NodePtr;
                   S      : Real;
                   MyNode : Node;
                   Name   : String64);

BEGIN
END;

FUNCTION Sieve: Integer;

VAR
  I,Prime,K,Count : Integer;
  Flags           : ARRAY [0 .. Size] OF Boolean;

BEGIN
  Count := 0;
  FOR I := 0 TO SIZE DO Flags[ I ] := TRUE;
  FOR I := 0 TO SIZE DO
    BEGIN
      IF ( Flags[ I ] ) THEN
        BEGIN
          Prime := I + I + 3;
          K := I + Prime;
```

```
        WHILE ( K <= SIZE ) DO
          BEGIN
            Flags[ K ] := FALSE;
            K := K + Prime;
          END;
        Count := Count + 1
      END
    END;
  Sieve := Count
END; { Sieve }

BEGIN  { Bencher MAIN }
  { Open timings file: }
  Assign(O,'TIMINGS.MS');
  Rewrite(O);
  Writeln(O,'Benchmark timings for MS Pascal V3.31: ');
  Writeln(O,' ');

  { Display 1000 64-character text lines to the screen via Writeln: }
  Write(O,'Beginning text display time test at     '); Show_Time(O);
  TextLine :=
  'AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA';
  FOR I := 1 TO 1000 DO Writeln(TextLine);
  Write(O,'                    done at     '); Show_Time(O);

  { Create linked list of 1000 8-byte nodes: }
  Write(O,'Beginning pointer chain time test at     '); Show_Time(O);
  New(Root);
  Current := Root;
  FOR I := 1 TO 1000 DO
    BEGIN
      New(Current^.Next);
      Current := Current^.Next
    END;
  Current^.Next := NIL;
  Write(O,'                    ...done at     '); Show_Time(O);

  { Dispose of a linked list of 1000 8-byte nodes: }
  Write(O,'Beginning chain dispose time test at     '); Show_Time(O);
  IF Root <> NIL THEN
    BEGIN
      REPEAT
        Current := Root^.Next;
        Dispose(Root);
        Root := Current
      UNTIL Root = NIL
    END;
  Write(O,'                    ...done at     '); Show_Time(O);

  { 30000 invocations of an integer function without parameters: }
  Write(O,'Beginning function call time test at     '); Show_Time(O);
  FOR I := 1 TO 30000 DO J := NullFunction;
  Write(O,'                    ...done at     '); Show_Time(O);

  { 30000 invocations of a proc with >80 bytes of parameters: }
  Write(O,'Beginning procedure call time test at    '); Show_Time(O);
  Current := NIL; R := 17.1776;
  TextLine :=
  'George Ian Howard Philips Macdonald Randolph Skeffington Bentley';
  FOR I := 1 TO 30000 DO TestProc(42,'Q',Current,R,TestNode,TextLine);
  Write(O,'                    ...done at     '); Show_Time(O);

  { 10000 evaluations of a complicated transcendental expression: }
  Write(O,'Beginning transcendental time test at    '); Show_Time(O);
  R := 3.14159;
  FOR I := 1 TO 10000 DO S := Sqrt(Sin(Ln(R)));
  Write(O,'                    ...done at     '); Show_Time(O);

  { 10 Iterations of the ever-popular Sieve of Eratosthenes: }
  Write(O,'Beginning Eratosthenes Sieve test at     '); Show_Time(O);
  FOR J := 1 TO 10 DO NCount := Sieve;
  Write(O,'                    ...done at     '); Show_Time(O);

  { Time text file create/1000 sequential line writes/file close: }
  Write(O,'Beginning text file write time test at  '); Show_Time(O);
  Assign(TextFile,'TEXTLINE.TXT');
  Rewrite(TextFile);
  FOR I := 0 TO 999 DO Writeln(TextFile,TextLine);
```

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The heart of EditCheck's contribution is a powerful C language program checker which provides strong type checking from within the editing environment. The checker does a thorough evaluation of your source code and detects common errors and questionable practices, including many that most C compilers will overlook.

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It also looks for functions called with a varying number of arguments.

In addition to the standard type checking performed by most compilers, EditCheck also looks for function arguments that do not agree in type with the arguments expected by the function. It looks for enumerated variables that are assigned values of a type other than that of the variable or that are used in operations not valid for enumerated types.

EditCheck complains about illegal type casts. At your option, it reports the assignment of longs to ints, of longs to chars, and of ints to chars.

The checker always reports when pointers refer to objects of different type.

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The editor uses a file paging scheme which allows you to edit and check modules larger than your available RAM memory. Any ASCII file may be read by the editor. Files may be inserted or appended to the current window file.

The editor is both key-command driven and menu driven, or mixed usage. Key-commands are fully user reassignable.

Windows, Files, and More

The EditCheck environment is window-oriented. You may have as many windows open at the same time as you wish. Windows may overlap or be tilted, at your option. You may switch back and forth between windows, and move or copy information between them.

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Windows are also extensively used by the EditCheck system to build commands, display help, show a module list, display messages, show program context while checking, etc.

A group of environment commands are available to change the coloring of windows (with a color graphics adapter and display), set the way you are notified of errors, and redefine the meaning of keys on the keyboard.

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Help is available to you in several ways. You may use a function key to get context sensitive help particular to where you are in the system. You may select the help index, and choose a topic of interest. You may also ask the help subsystem to search for a particular word of interest within the entire system. Display of current keybindings is also available.

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```
Close(TextFile);
Write(0,'                                ...done at  '); Show_Time(0);
{ Time text file open/1000 sequential line read/file close: }
Write(0,'Beginning text file read time test at   '); Show_Time(0);
Assign(TextFile,'TEXTLINE.TXT');
Reset(TextFile);
FOR I := 0 TO 999 DO Readln(TextFile,ReadText);
Close(TextFile);
Write(0,'                               ...done at   '); Show_Time(0);

WITH CustRec DO    { Fill the test record with reasonable data: }
  BEGIN
    CustNum := 0.0;
    CustName := TextLine;
    Current := True
  END;

{ Time file create/1000 sequential record writes/file close: }
Write(0,'Beginning sequential write time test at '); Show_Time(0);
Assign(CustFile,'TESTDATA.BIN');
Rewrite(CustFile);
FOR I := 0 TO 999 DO      {Write(CustFile,CustRec);}
  BEGIN
    CustFile^ := CustRec;
    Put(CustFile)
  END;
Close(CustFile);
Write(0,'                                ...done at '); Show_Time(0);

{ File open/1000 random read-update-in-place operations/file close:}
Write(0,'Beginning update-in-place time test at  '); Show_Time(0);
Assign(CustFile,'TESTDATA.BIN');
CustFile.Mode := DIRECT;  { MS Pascal only }
Reset(CustFile);
FOR I := 999 DOWNTO 0 DO
  BEGIN
    Seek(CustFile,I+1);
    Get(CustFile);
    NewRec := CustFile^;
```

```
      NewRec.CustNum := I;
      CustFile^ := NewRec;
      Seek(CustFile,I+1);
      Put(CustFile);
    END;
  Close(CustFile);
  Write(O,'                         ...done at  '); Show_Time(O);

  Close(O)
END.
```

LISTING 2: MATRIX2.PAS

```
{$real:8}
{$floatcalls-}
PROGRAM MATRIX(INPUT,OUTPUT);  { For MS Pascal }

(* By Alan R. Miller; modified by Jeff Duntemann *)
(* from: PASCAL PROGRAMS FOR SCIENTISTS AND ENGINEERS *)
(* (c) 1981 by Sybex, Inc. *)

CONST
  RMAX = 20;
  CMAX = 20;

TYPE
  ARY    = ARRAY[1..RMAX] OF REAL;
  ARYS   = ARRAY[1..CMAX] OF REAL;
  ARY2   = ARRAY[1..RMAX, 1..CMAX] OF REAL;
  ARY2S  = ARRAY[1..RMAX, 1..CMAX] OF REAL;
  STRING80 = LSTRING(80);

VAR
  Y      : ARY;
  G      : ARYS;
  X      : ARY2;
  A      : ARY2S;
  NROW,NCOL      : INTEGER;
  CH     : CHAR;
  I : INTEGER;
```

PASCAL

```
  O : TEXT;

FUNCTION TICS : WORD; EXTERN;
PROCEDURE TIME(VAR S : STRING); EXTERN;

PROCEDURE Show_Time(VAR Outfile : Text);

VAR
  TimeString : LSTRING(15);

BEGIN
  TimeString := '        ';
  Time(TimeString);
  Writeln(OutFile,TimeString,'.',Tics:2);
END;

PROCEDURE GET_DATA(VAR X : ARY2;
                   VAR Y : ARY;
                   VAR NROW,NCOL : INTEGER);

(* Get values for NROW, NCOL, and arrays X, Y *)

VAR I,J : INTEGER;

BEGIN
  NROW:=10;
  NCOL:=10;
  FOR I:=1 TO NROW DO
    BEGIN
      X[I,1]:=1;
      FOR J:=2 TO NCOL DO
        X[I,J]:=I*X[I,J-1];
      Y[I]:=2*I
    END
END;    (* GET_DATA *)

PROCEDURE WRITE_DATA;

(* Print out the answers *)
```

```
VAR I,J : INTEGER;

BEGIN
  WRITELN;
  WRITELN('      X                          Y');
  FOR I:=1 TO NROW DO
    BEGIN
      FOR J:=1 TO NCOL DO
        WRITE(X[I,J]:9:1,' ');
      WRITELN(':',Y[I]:9:1)
    END;
  WRITELN;
  WRITELN('      A                          G');
  FOR I:=1 TO NCOL DO
    BEGIN
      FOR J:=1 TO NCOL DO
        WRITE(A[I,J]:10:1,' ');
      WRITELN(':',G[I]:10:1)
    END
END;  (* WRITE_DATA *)

PROCEDURE SQUARE(X       : ARY2;
                 Y       : ARY;
                 VAR A   : ARY2S;
                 VAR G   : ARYS;
                 NROW,NCOL : INTEGER);

(* Matrix multiplication routine *)
(* A = transpose X times X       *)
(* G = Y times X                 *)

VAR I,K,L : INTEGER;

BEGIN  (* SQUARE *)
  FOR K:=1 TO NCOL DO
   BEGIN
     FOR L:=1 TO K DO
       BEGIN
         A[K,L]:=0;
         FOR I:=1 TO NROW DO
           BEGIN
             A[K,L]:=A[K,L]+X[I,L]*X[I,K];
             IF K<>L THEN A[L,K]:=A[K,L]
           END
       END;    (* L loop *)
     G[K]:=0;
     FOR I:=1 TO NROW DO
       G[K]:=G[K]+Y[I]*X[I,K]
   END         (* K loop *)
END;  (* SQUARE *)

BEGIN   (* MAIN *)
  { Open timings file: }
  Assign(O,'MATTIME.MS');
  Rewrite(O);
  Writeln(O,'Matrix benchmark timings for Microsoft Pascal V3.31: ');
  Writeln(O,' ');

  WRITE(O,'>>Starting matrix multiply time test at ');
  SHOW_TIME(O);
  FOR I := 1 TO 10 DO
    BEGIN
      GET_DATA(X,Y,NROW,NCOL);
      SQUARE(X,Y,A,G,NROW,NCOL);
    END;
  WRITE(O,'                              ...done at ');
  SHOW_TIME(O);
  CLOSE(O);
  WRITE('>>Press (CR) to display the matrix: ');
  READLN;
  WRITE_DATA
END.
```

LISTING 3: CBENMS.BAT

```
TIME 0:0:0
PAS1 /Q BENCHER.PAS,BENCHER.OBJ,NUL,NUL
PAS2
LINK BENCHER.OBJ,BENCHMS.EXE,NUL,,PASCAL.LIB
TIME
```

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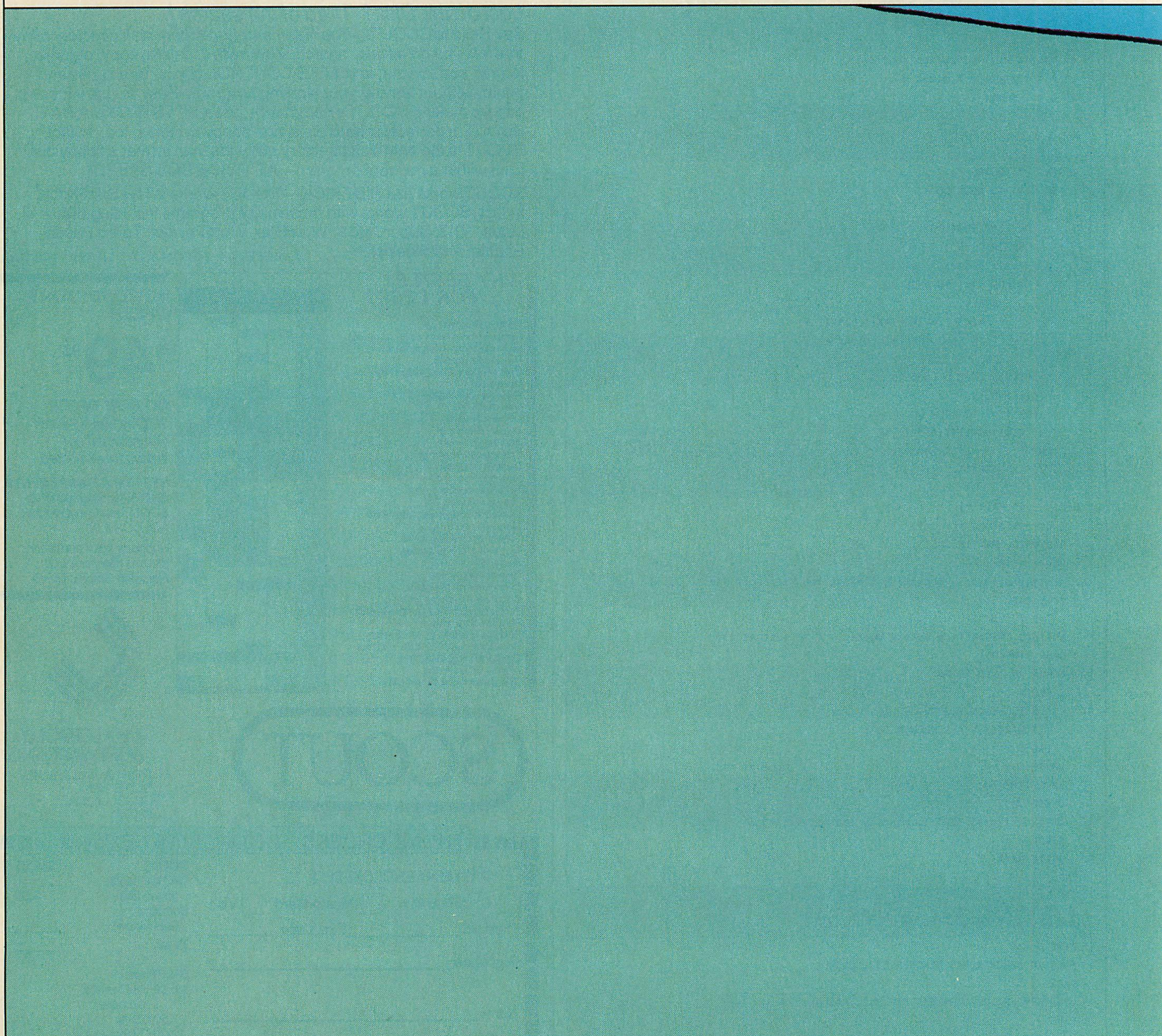

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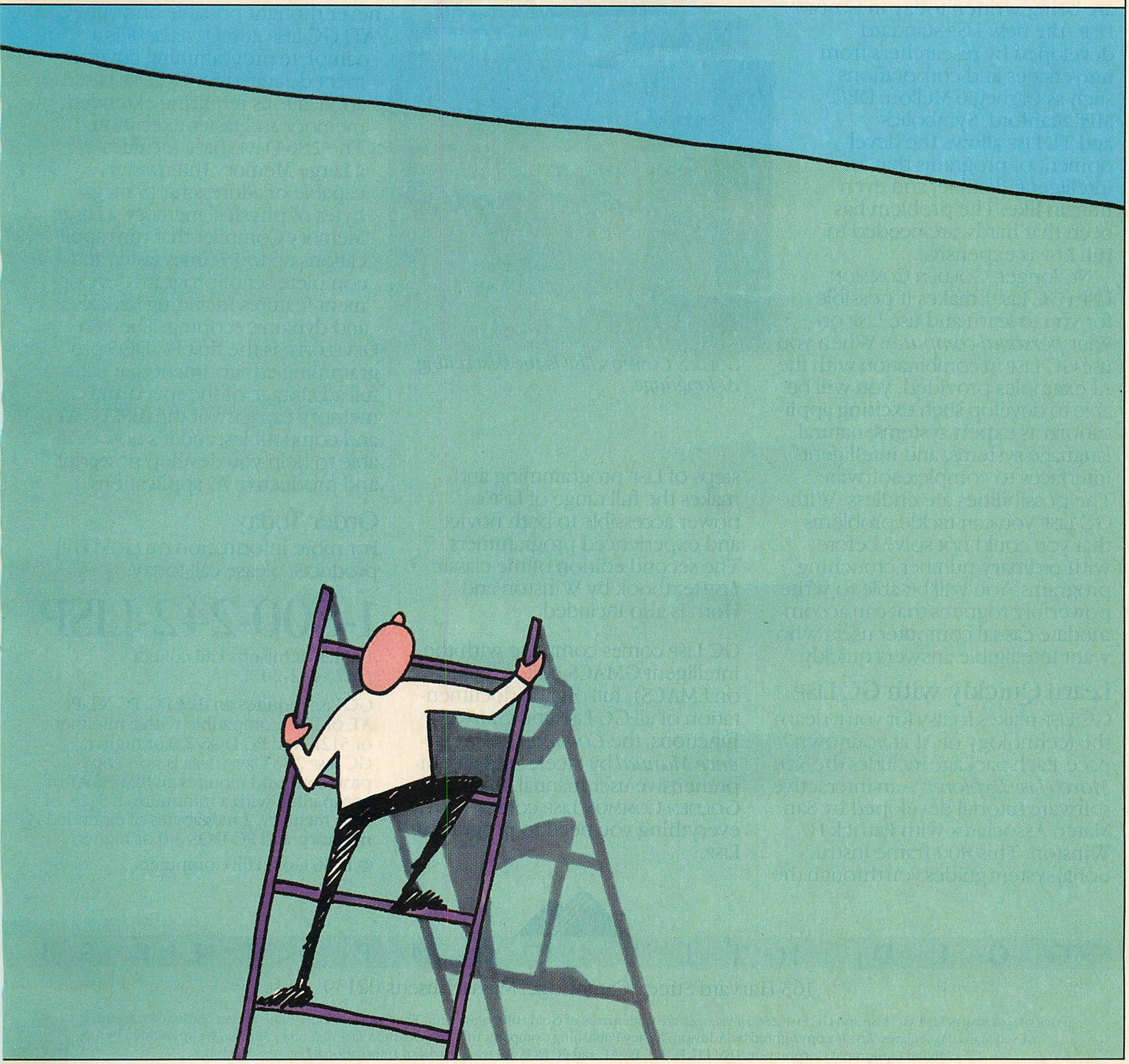

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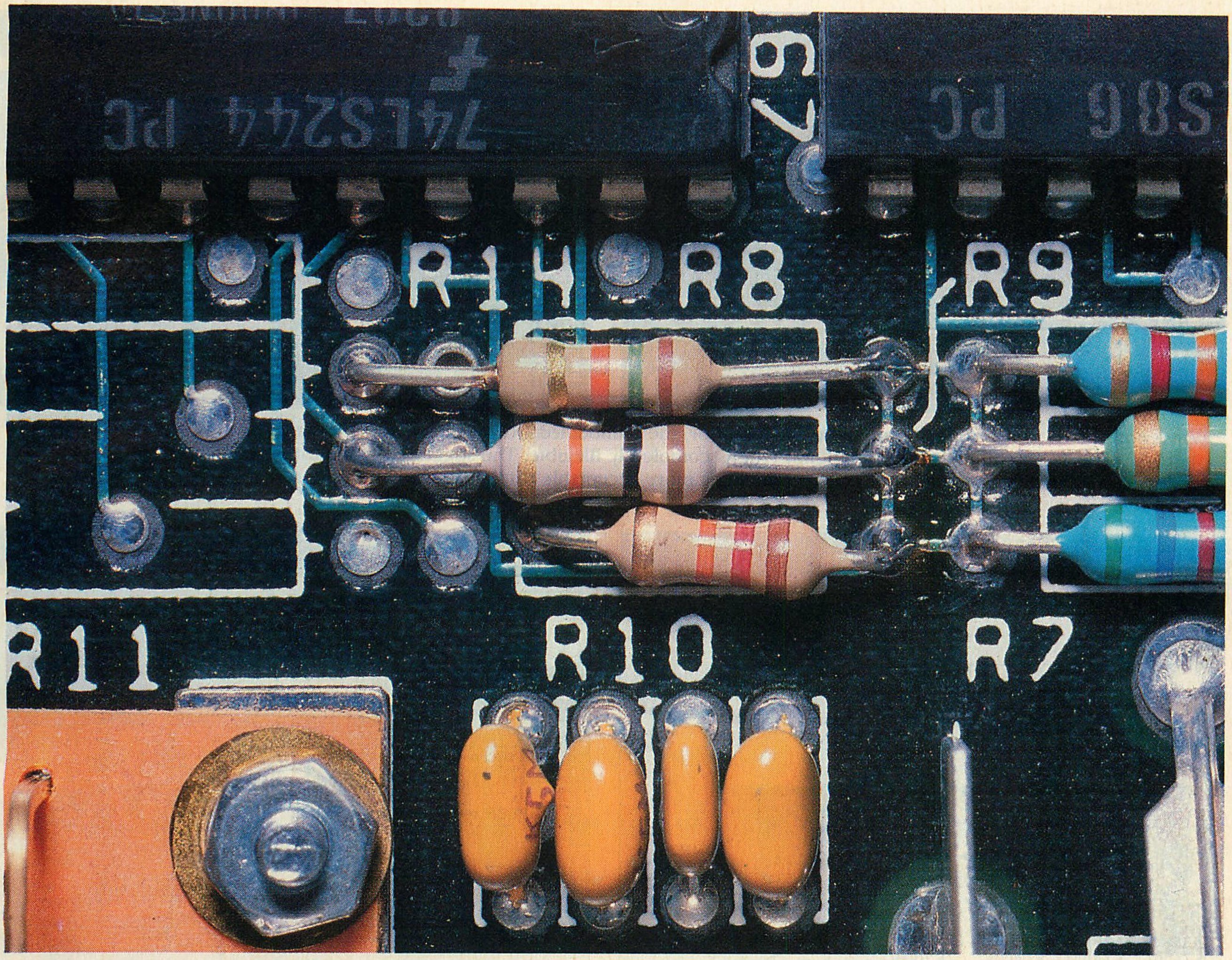
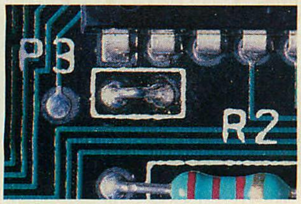
CIRCLE NO. 122 ON READER SERVICE CARD





A Better CGA

MICHAEL COVINGTON

Two hardware modifications to the CGA may improve the display on an RGB color or a composite monochrome monitor.

Top: The modification to the CGA is a simple addition of resistors. The three resistors result in 16 shades of gray.
Bottom: Jumper P3 is a pair of holes at the edge of the MC6845PIC, which is joined with wire. This selects a thinner font.

A better picture may be possible using the IBM Color Graphics Adapter (CGA) with a composite monochrome or an RGB color monitor. Two hardware modifications presented here can help improve the functionality of the CGA. The first removes the striping effect that occurs on monochrome monitors running color programs. It allows the CGA to render its 16 colors as distinct shades of gray. The performance of the board with an RGB monitor is unaffected. The other modification allows the user to select an alternative character set to the standard font supported by the CGA.

Although these changes may improve the quality of the CGA, an important consideration is that any alteration to the IBM hardware will void its war-

PHOTOGRAPHS THIS PAGE • JOHN LEI

PHOTO 1: *Striping Effect*

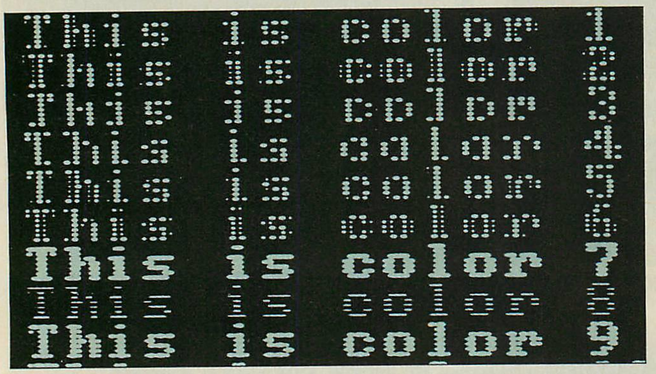
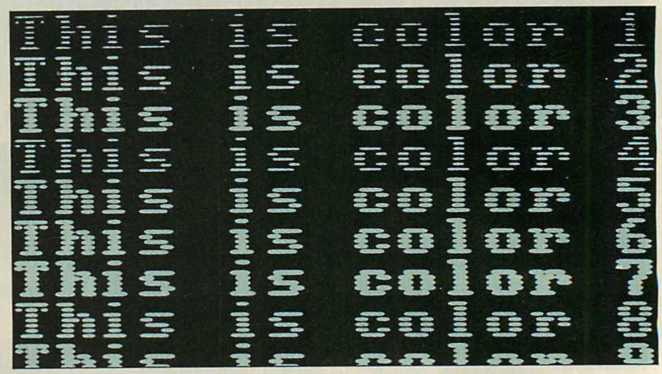
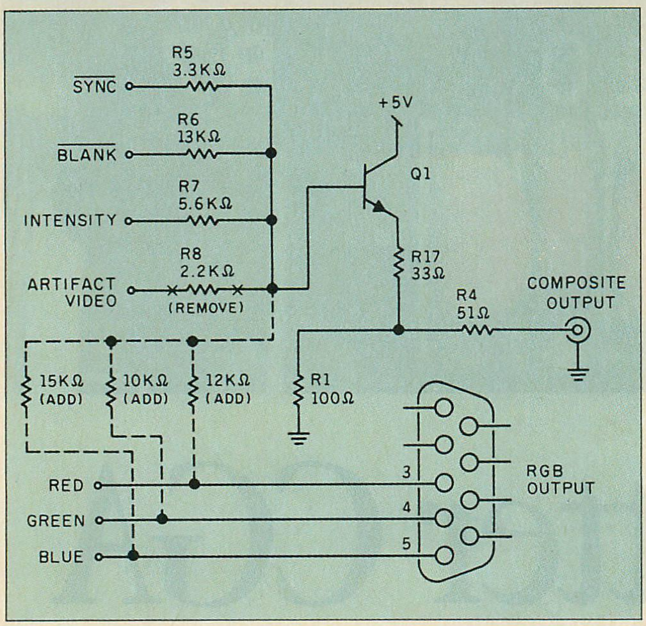


PHOTO 2: *Modified Striping Effect*



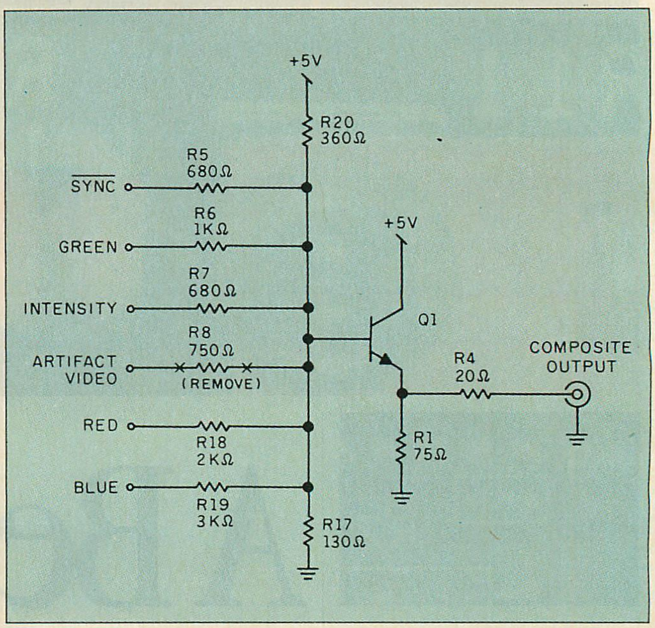
When connected to a composite monochrome monitor, the unmodified CGA renders colors as patterns of stripes (shown in photo 1). This is 40-column type; 80-column type is completely illegible. The suggested modification eliminates the stripes and renders colors as different shades of gray, producing a more acceptable display (as shown in photo 2).

FIGURE 1: *Original CGA*



The original CGA circuit board can be modified by removing R8 and adding a portion of the red, green, and blue signals. (This information is from the *IBM Technical Reference Manual*, part 1502234.)

FIGURE 2: *Newer CGA*



The newer version of the CGA requires only that the resistor R8 be removed to render colors as shades of gray. (This information is from the *IBM Technical Reference Manual*, volume 2, "Options and Adapters," part 6137806.)

ranty. These changes also preclude the CGA's use with televisions.

When the CGA was first introduced, televisions sometimes were used as the display for the PC. Therefore, IBM designed the CGA to accommodate televisions as well as the RGB color and composite monochrome monitors that most people use today.

SHADES OF GRAY

This support of color television, however, results in a distracting effect when a monochrome monitor is connected to the CGA. Colors are displayed as patterns of stripes (photo 1). This can make a text screen difficult to read.

The stripes exist because PCs generate *artifact color*. In American color television broadcasting, under guidelines of the National Television System Committee (NTSC), color information is transmitted on a 3.58-MHz subcarrier embedded in an otherwise ordinary black-and-white video signal. As a result, NTSC color broadcasts can be received on black-and-white television sets. PCs, however, do not actually use a 3.58-MHz subcarrier. Instead, they render colors as patterns of stripes in which the video frequencies are exact submultiples of 3.58 MHz. A television connected to a PC is fooled into responding as if the subcarrier were present. No real color signals are transmitted—the colors are artifacts of the phase and frequency of the stripes.

IBM recently has modified the CGA in an effort to make the stripes somewhat less troublesome. The modified version includes three additional resistors, which are configured as a voltage divider that provides a proportion of the red, green, and blue color signals to the composite video output.

Several digital signals are mixed to form the composite video signal. The original CGA circuit board had a signal for the synchronization pulses, one for blanking, one for high or low intensity, and one containing various 3.58-MHz

PHOTO 3: *RGB Monitor*

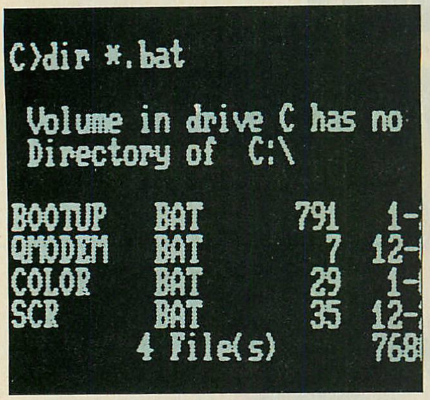
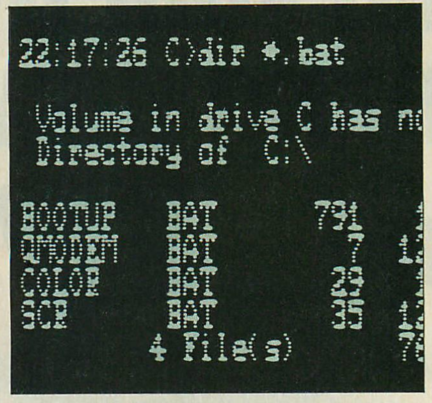
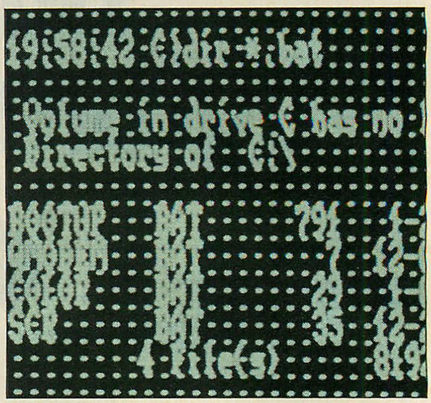


PHOTO 4: *Monochrome*



When the jumper P3 is connected on some CGAs, the alternative typeface is very legible on an RGB monitor (photo 3). The character is a 7-high-by-5 wide single-dot font with one descender. The alternative typeface is disappointing on the composite monitor (photo 4). Removal of the jumper restores the original font.

PHOTO 5: *Dot Pattern*



Selecting the alternative font resulted in a dot pattern on an RGB monitor. This was due to a defective character generator IC on the author's CGA.

components for generating artifact color. The mixing of the signals takes place in a network of resistors that are connected to the base of transistor Q1. Figure 1 shows an excerpt from the IBM schematic for the CGA board that illustrates the original circuit.

In the newer circuit (figure 2), the blanking signal has been replaced with the red, green, and blue drive signals. As a result, the stripes appear on a gray rather than a black background, thereby increasing legibility.

While IBM now has softened the effect of the stripes, the distraction can be eliminated entirely by removing resistor R8 to block the signal that contains the 3.58-MHz components. In IBM's newer circuit board, no other changes are necessary; resistors R6, R18, and R19 translate colors into shades of gray automatically. In the older circuit board, however, three resistors must be added to construct a composite gray signal from red, green, and blue drive signals borrowed from the RGB monitor socket. (The load on the RGB outputs is negligible, and performance of RGB monitors is not affected.) The new circuitry is indicated in figure 1 by the dotted lines. Photo 2 shows the result of the modification. The values for the resistor were chosen to ensure that each combination of red, green, or blue intensities would produce a different level of gray. If any two of the chosen values had been the same, several of the gray levels produced also would have appeared the same.

The large photo featured at the beginning of this article illustrates one method of installing the new resistors. The three resistors are placed on the circuit board so that one side is connected to the base of Q1, and each of the other sides is connected to the red, blue, or green signal, as appropriate. Before proceeding in this manner, however, users should examine the circuit board closely. Some early model CGAs already include places on the board for these three resistors.

In addition to eliminating the stripes, this modification corrects a problem with horizontal synchronization sometimes encountered on older CGAs. On some monitors, lines displayed in reverse video, such as the status line of an editor, pull to the left or the right relative to the other lines. This occurs because the synchronization pulse generated by IBM's circuit is too small. According to the NTSC standard, synchronization pulses should constitute 25 percent of the amplitude of the entire video signal. The modification described above enlarges the synchronization pulses of the IBM circuit so they conform to the standard size.

The rendering of colors as shades of gray is most effective when the monitor is adjusted for relatively high brightness and low contrast—the background is not pitch black, and the entire range of shades from very dark to very light is distinguishable. A few color combinations still may be difficult to read, but none is absolutely illegible (as they would be if rendered as stripes).

THE SECOND TYPEFACE

The IBM *Technical Reference Manual* states that the CGA supports two typefaces in text mode, selectable by a jumper referred to as P3. The standard typeface (a 7-by-7 double-dot font) is selected by removing the jumper. When the jumper is in place, a 7-by-5, single-dot font with thinner vertical strokes is invoked. (See "The IBM Color Graphics Adapter," Thomas V. Hoffmann, July-August 1983, p. 26.)

The thinner typeface is slightly more legible than the standard face on RGB color monitors (photo 3). On composite monochrome monitors, however, the vertical strokes are almost too thin to see, and the entire display can end up looking like a scattering of horizontal dots and dashes (photo 4).

Only the earliest model CGAs have a jumper marked P3 installed; in its place, later CGAs contain just two "plated-through" holes in the circuit board. Installing the jumper requires the user to solder a piece of wire between the two holes in order to connect them (refer to the small photo at the beginning of the article).

Photo 5 shows an odd problem that became apparent when jumper P3 was added to the CGA—the screen was covered with dots. Examining the contents of the character generator integrated circuit revealed that two extra bits were set in the definitions of characters 0-127 in the thinner typeface.

The integrated circuit that caused the problem pictured in photo 5 had a date stamp of 8252 and a copyright date of 1981. *PC Tech Journal* was not able to establish if this is an isolated problem or whether other character generators share the defect, which is undetectable during normal use and testing. If the problem occurs, the jumper should be removed, and the user will be no worse off than before.

Michael Covington is a research associate of the Advanced Computational Methods Center at the University of Georgia.

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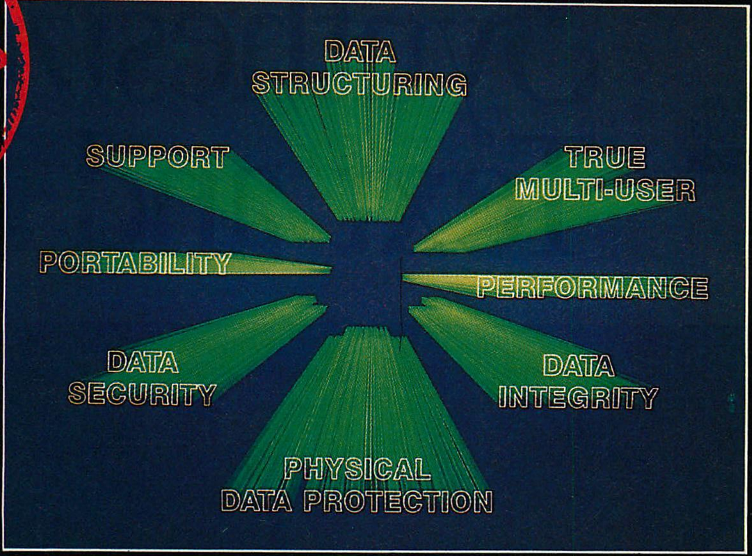

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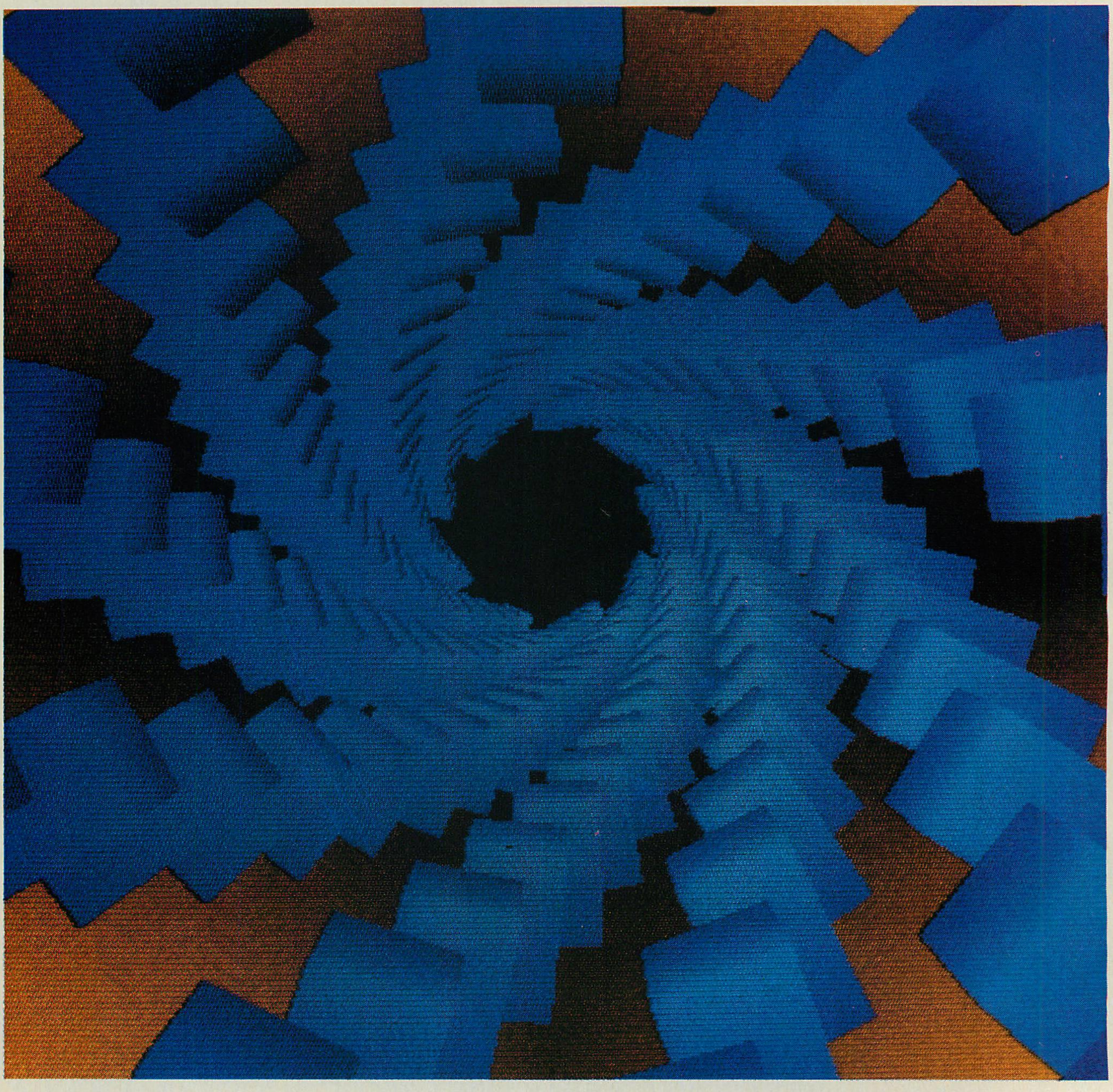


COMPUTER GRAPHIC • DOV JACOBSON

A sophisticated integration of text and data management and an easy user interface are hallmarks of Metafile.

V. JOSEPH BOWMAN

Introduced in 1980, the Metafile data management package is deeply rooted in the mainframe environment, and many of its features and methods of processing reflect this. Metafile Information Systems has set as the target market for its product independent developers, MIS/DP professionals, and business managers.

Among Metafile's hallmark characteristics is a sophisticated integration of text and data management. Text is handled within a program in much the same way that data are manipulated. At any given time Metafile has two active areas—one for data and the other for text. Data files have the normal structure of fields within records, while text files have an equivalent structure of words within text. The integration of these concepts allows for root commands that operate on either of the areas by the inclusion of the simple qualifier RECORD or TEXT.

In addition to the text area being under program control, it is also used for the creation of procedures, menus, and reports. Any of these can be accessed directly by specifying TEXT instead of a file name.

Metafile also provides a rich set of commands for developing end-user interfaces. The system has an interactive menu mode (called the Assistant) that uses these commands to aid the user in the manipulation of either text or data. Help is provided in the form of an incomplete command processor that automatically takes the user to the appropriate pull-down menu and allows correct completion of the command. All of these features reflect a concern for easy user interface whether in the interactive or program mode.

The Metafile package consists of two diskettes—one contains the Metafile program, and the other is a demonstration disk. Metafile's method of copy protection is a configuration device that plugs into the COM1 port and has pass-through capabilities in case COM1 is used for communications. If the device is not present when Metafile is started, the system is automatically configured to a restricted demonstration version. Although installation of the device requires a screw driver, once it is on the computer, the user can forget about copy protection. Because a demonstration version of Metafile is available on machines without the configuration device, a developer can demonstrate an application without having to install and uninstall hardware.

Metafile has been designed to run on IBM microcomputers, but may run on systems that are not 100-percent compatible. Metafile Information Systems provides a list of hardware on which compatibilities are reported.

DATABASE DESIGN

Metafile is not a relational database system. It has no commands for joining multiple files or for linking files together for automatic repositioning. Relating files must be done under program control. Metafile allows up to five files to be active. At any given time only one of the active databases is the primary database, but access to data elements in the current record of other active files is provided by specifying the field name, or if the field name is not unique, the file name and field name, such as AUTHOR LAST_NAME. Metafile therefore is able to support a quasi-relational structure with the relation being preserved either by a program or by interactive commands.

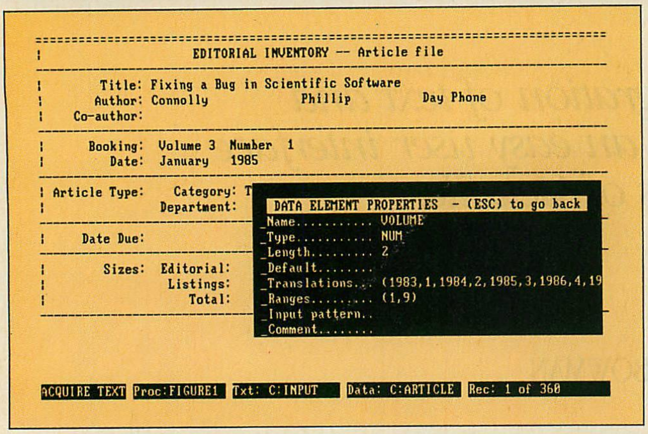
Each Metafile data file requires at least three DOS files and sometimes as many as five. The data are stored in .DAT files, the data description in .DES files, and the logical sequence and physical location of the records in .SSD files. The .DAT and .SSD files have the same prefix while the .DES description file may be shared between many data files. An index file (.SSI) exists if a file is keyed, and a data recovery file (.SSR) is used if the file is set for manual updating. Other temporary work files are created by Metafile as needed.

Data are stored in variable length records as ASCII characters, with fields separated by commas. The end of record is the standard ASCII end of line sequence—carriage return and line feed—and the end of file is marked with a Ctrl-Z. Double quotes are used in data storage only when a field contains characters other than a letter, digit, or decimal point. This method of storage allows data to be manipulated without concern for type. Thus, a character variable can be set equal to a numeric value without a conversion function.

In processing updates to the database, Metafile generates a new record for each one that has been changed. The first value in each record is a status byte that indicates whether this is the current value of the record. This value is used internally by Metafile; it is not displayed with the record and cannot be read or modified by the user. While creating a new record instead of overwriting the changed record causes the data file to grow even when no records are being added, it also allows for a program-controlled update procedure to guarantee data integrity and recovery of the data after a system crash.

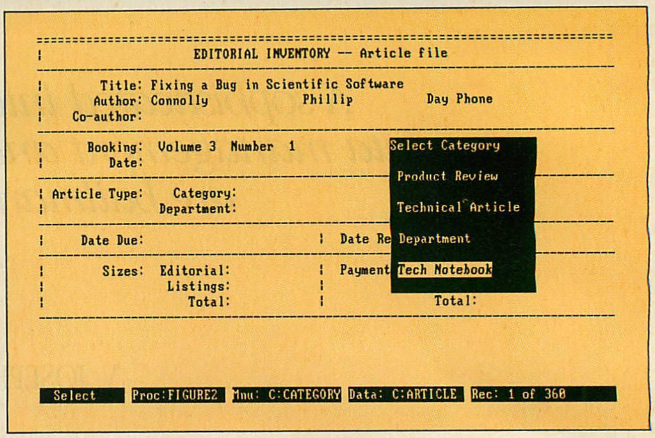
When data files are initially described, they must be set for either automatic update, in which every change is permanently recorded in the

PHOTO 1: *Field Validation Properties*



Extensive editing and validation criteria can be defined for each field. During data entry, pressing the Ctrl-L combination reveals the criteria for the field being entered.

PHOTO 2: *Data Validation Using Menus*



Besides offering the user choices of action, the menu can be used to ensure valid input of data. For department name, the user must select one of the four options presented.

database, or manual update, in which the data are not permanently recorded until a KEEP command is issued or the data file is closed. During an update, DISCARD causes all records changed since the last, permanent update to be reset to their previous value. This is especially useful in transaction processing and is used by many mainframe databases to guarantee that a set of related records either are all added to the database or are backed out of it.

Because all changes generate additional records, care must be taken periodically to copy a data file to itself and eliminate all old record images in addition to any records that have been deleted. Because data are stored in variable-length form—a null data item requiring only one byte for the field-separating comma—the size of files can be substantially smaller than that of a fixed-record-length file even with the multiple record images.

The data description file (.DES) contains information on the data fields, which is used by Metafile to interpret the data file and provide automatic data entry validation and output formatting for interactive update. *Item Name* can consist of up to 40 characters. *Data Type* can be character, numeric, or date. *Length* is the maximum space needed to store the variable and must include space for translations and input or output patterns. *Position* specifies the field number in a data record, which allows multiple descriptions to be given to the same data item. Input validation and output formatting of the data item then depends on the name by which the data item is referenced. (Automatic validation and output formatting are effective only during keyboard input, not through procedural updates.) *Default value* either is a standard value or specifies required input if the value is "?". Multiple *ranges* can be declared by entering multiple paired groups. Thus, 0,5,8,9 is a valid range that allows only the values 0, 1, 2, 3, 4, 5, 8, or 9. *Translation* provides automatic checking of input for particular values and also allows translation of coded input. The sequence, Male,M,Female,F, causes only the four values specified to be accepted for entry, and if *M* or *F* is entered, all output will translate these values to either Male or Female. Finally, standard *input* and *output patterns* can be specified along with a 250-character comment. This set of field information is automatically presented when the help key (Ctrl-L) is pressed during data input, as shown in photo 1.

Arrays, which are supported for the storage of either variables or data items, do not have to be dimensioned. An array is any sequence of characters delimited by commas, spaces, or quotes. This general definition provides tremendous power in both variable and data element manipulation. Each dimension in an array is denoted by a grouping of parentheses; the only limit on the number of dimensions is the maximum supported array length of 235 characters, including element separators. Arrays provide an alternative method of processing text because each sequential element is a word.

Numeric fields have an arithmetic accuracy of 20 digits but are limited to a length of 16 in keys and in sorts. Character fields have a maximum length of 235 characters while character variables may be 250 characters long. Date fields are in the form DDMMMYY or DDMMMYYYY, with dates ranging from 01JAN1776 to 31DEC9999.

Up to three keys are allowed for each file. A key must be a field, and if the key value is not unique, only the first occurrence is maintained. If the record associated with a key value is deleted, this value also is eliminated from the key file even if the value exists on another record.

Because Metafile runs on DOS 1.1 and above, it does not support path names. All files are assumed to be in the current directory on the default drive, which must also contain the Metafile program. If files reside on another drive, the drive must be specified.

APPLICATIONS LANGUAGE

The applications development language of Metafile contains the standard looping structures of WHILE, WHERE, FOR, and IF. The WHERE command can control a loop of operations to be performed on records meeting specified conditions. No standard CASE command is provided. Procedures and loops may be nested 22 deep. The maximum storage available for variables is 4,100 bytes. Variables assigned values via the SET command are global. Parameters are passed between procedures by two reserved arrays, PASSED and RETURNED, which are limited to 250 characters; the user may define as many parameters as are necessary to meet this size restriction. Parameters do not use storage as variables do; the values of the parameters are local to the procedure to which they are passed or returned.

The language is an interpreted one, and the commands of a procedure file are displayed on the status line as they are executed if STATUS is ENABLED. All

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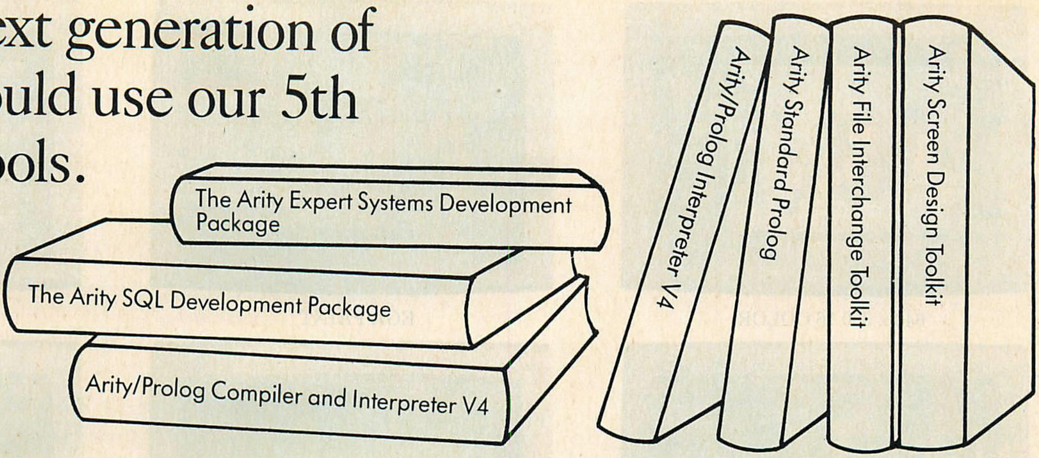

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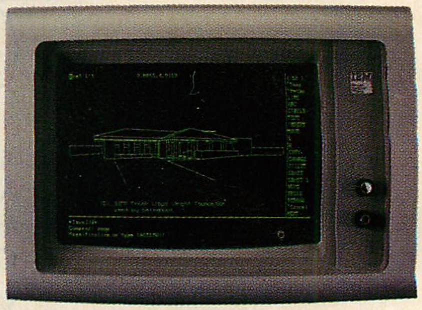

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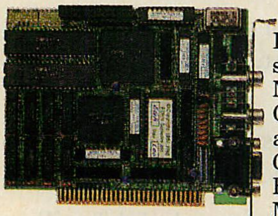

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Chip count	24	29	86	40
Hercules compatible 720 x 348 graphics	✓	✓		
No Software Patches required	✓		✓	✓
Boot from:				
— Flight Simulator	✓			
— Pin Ball	✓			
— Jet	✓			
Runs Lotus 1-2-3 version 1A:				
— Hercules mode	✓	(1)		
— Color mode	✓	(1)		
Two Video Jacks	✓	✓	✓	
Display Memory	256K	256K	64K	256K
Light Pen connector	✓	✓	✓	✓

(1) Needs software driver patches.
(2) Compatible only to the BIOS level, but not the hardware level. Will not be compatible with most games software.

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commands in Metafile must be typed in uppercase letters. The use of lowercase letters causes syntax errors.

String manipulation is available by functions that return the left or right portion of a string. Numeric functions include logarithms, absolute values, and two functions—EVEN() and ODD()—that return TRUE if an expression is even or odd. Dates can be added or subtracted from each other and converted to various formats. In addition, special functions such as determining the end of month and adding or subtracting a specified number of months also exist. No support of 8087 math coprocessors is provided.

The interface to DOS is via a 125-line assembly program called SUBMIT, which is listed in chapter 14 of the *User's Guide* and is part of the Utilities package in the optional Timesavers series. In addition, up to 10 serially reusable .COM files can be specified in the parameter string at start-up. These files become memory resident and are directly accessible from Metafile.

Debugging tools for procedures include single-step execution. The Assistant interactive menu mode can be used to display the active context—that is, the properties of the data items of the primary data file, current values of variables, and information about active files, current display frames, and report output destination. In addition, procedures are developed in the text areas, and a selected block of code can be executed from the edit process. This feature, coupled with the ability to enter the data area with the text area still active, allows detailed investigation of the results of this execution and quick correction of any errors. Program optimization is left to the developer.

Language interfaces are limited to Metafile execution of .COM files or DOS execution of .COM, .BAT, and .EXE files using SUBMIT. Thus, direct parameter passing between Metafile and other languages is not possible except by file generation. However, using Metafile's integration of text processing and its array capabilities, creation of files for exchanging data between programs in other languages can be as straightforward as direct parameter processing, although not as efficient.

Menu screens are also generated in the text area and may contain text, data, and formulas. SELECT <menuname> invokes a menu, treating any item enclosed in brackets as a menu option. The full cursor keypad is available for movement between these options, including the PgUp, PgDn, Home, and End keys. When the cursor is on a menu item, the option is displayed in reverse video. A menu item is selected by pressing Enter, and the result of the selection is available for program processing in the system variable OPTION.

DATA ENTRY AND UPDATE

Screens are generated in the text area. The text is typed as needed. Input and output fields are described by pressing the Attention key and then selecting the option F for fields. The field is located at the editing location on the screen being prepared. Characteristics of the field can be described, and the default descriptions for the data element can be overridden, including display formats, ranges, translations, and whether the item is required for input. This gives the developer a wide range of control over data element validity checking on a screen-by-screen basis. Because a screen is executed in the text area, it can consist of multiple pages, with the PgUp and PgDn keys used to move between the screens.

The fields are sequenced in the order that they are placed on the screen; this allows full-screen mode to be used. It also allows an output field to represent the total of several other fields, as long as the total is preceded by its elements. In addition to fields, the results of any calculable operation can be displayed.

Entry of data via input screens automatically checks for validity of input against the current description. An error will cause an error message, and the item description is available using the help key (Ctrl-L). Variables can be displayed only (no input is allowed).

Access to programs and data elements can be controlled programmatically using the built-in functions ID and _SERIAL. ID is the value of the session name specified upon the user's entry into Metafile and may be used as a password. _SERIAL is the serial number of the current operating Metafile program. Metafile also provides the SECURE command, which encrypts procedure files so that checking of these variables can be protected from modification.

Deleted records are not eliminated from the data file until the file is copied. A file that is constantly being changed should be copied to itself on a regular basis to control file size growth and to ensure speedy access to data.

Metafile's method of accessing data based on criteria and sequence is reminiscent of some mainframe data managers. Metafile uses a record qualification method that builds a pointer file of

all records meeting a criteria specified in a FIND command. These qualified records are the only ones available for access until the criteria are lifted—via another FIND command, for example. Disqualified records can be added to the qualified set using ALSO.

FIND and ALSO must make one pass of the entire data file to build the pointer file while subsequent commands work directly on only the qualified records. This makes Metafile efficient in situations requiring a single qualification and multiple passes through the qualified records, such as producing several types of reports under one criteria. However, Metafile is less effective in situations requiring multiple qualifications and a single operation such as producing the same report for different criteria. In the latter case, for each report the entire database is passed once for qualification, and then all qualified records are again processed for the report.

Metafile supports a keyed access structure for quick access to specific records. Each key must be a single data field and is automatically updated during the input process. The number of keys is limited to three. Access to keyed values is by means of the command POINT <key> = <value>. Multiple valued keys are not supported, so only one record is accessible for a given key value. If the records are sorted by key value, the additional records corresponding to the value are accessed by using the NEXT command. If a keyed record is deleted, the key value is lost even if another record has that key value. These restrictions on keys limit Metafile's effectiveness to data files that contain only unique key values.

Physically, the records are stored in the sequence in which they are added to the data file. In order to access the data sequentially in some other order that involves multiple data item values, the file must be sorted. Because the sort is only on qualified records, it is similar to a temporary index. The records are not physically rearranged and the original sequence is restored on completion of use of the data file or on a new criteria specification. The sorting criteria can be any number of fields as long as the sort key is less than 250 characters. Fields can be sorted in either ascending or descending order.

REPORT CAPABILITIES

Metafile provides four methods of producing report output: columnar via LIST, multi-up via LAYOUT, report form text files, and programs. The destination of the output can be the screen, printer, or the text area.

As with most Metafile commands, LIST either can be typed as a command or programmed through menu selection. LIST produces a standard columnar report with up to three levels of control break. Averages, totals, and counts are available at each break level. Outputting of duplicated values can be suppressed so that changes in field values can be easily discerned. Headings can also be specified for each field.

The LAYOUT command produces multi-up reporting that is useful in generating mailing labels. A text file is created in which the size in rows and columns is specified and fields are named within curly braces. Text also can be entered. This text file is then named in the LAYOUT function along with the number of repetitions across the page producing the multi-up report.

Report formats are produced in the same manner as the text files for labels. However, any Metafile command can be included in these reports so that looping and value assignments can be made. The result is a completely flexible reporting technique that incorporates both report painting and programming control. An example of placing command structure within a report would be the use of IF statements to produce completely different text depending on values of a particular field.

The report format is written to the printer by the PRINT command. Because reports allow for any valid Metafile command to be placed in the text, other report formats can be merged into a report by using the PRINT command within the report.

Specifications for the reports or layouts are provided by a series of commands in the text of the report format or layout. These can be Metafile commands preceded by a % character, or they can be special printing commands that control page ejection, spacing, page depth and width, forms length, indenting, number of copies, headers, footers, and printer control codes. Most of these have system variable counterparts so that values can be tested or included in the report itself.

Metafile does not provide any utility for rebuilding damaged files; nor is transaction logging available. However, the manual updating procedure provides the developer with a powerful tool for maintaining data integrity. Data integrity can be guaranteed by specifying the data file for MANUAL update and using the KEEP or DISCARD functions after integrity has been checked.

METAFILE OVERVIEW

Metafile, version 8.2
Metafile Information Systems, Inc., 401 16th Street S.E., Rochester, MN 55904; 507/289-8967

Product type. A data manager that features a rich screen and reporting command structure, a delayed data update feature to ensure data integrity, and innovative use of a text buffer not only for standard editing but also for program-controlled text processing and the creation of menus.
IBM PC environment. PC, PC/XT, PC/AT, or 100-percent compatible running DOS 1.1 or higher with two floppy disk drives, or one floppy drive and a hard disk, a monochrome or a color monitor, and one serial port. A system configured with the minimum RAM (128KB) provides restricted text, sort, and variable capabilities—320KB are required for a full capacity system.
Other environments. Metafile's design is based on IBM hardware, but the program is able to run on some nearly compatible systems. These systems require a non-IBM configuration device or the runtime version only. A list of reported compatibles can be obtained from Metafile.
Network support. Metafile supports LANs compatible with the IBM PC Network. The LAN Toolkit provides utilities for interfacing to 3Com's Ether-Share, PCnet, and Novell NetWare.
Copy protection. Metafile is not software copy protected. Hardware copy protection is provided via a special configuration device that attaches to COM1. Absence of the device restricts the system to use as a limited capacity demonstration version.
Documentation. Documentation for Metafile consists of three volumes. One volume contains an *Installation Guide* (60 pages) and a *Quick Orientation Guide* (50 pages); the second contains a 14-chapter *User's Guide*; and the third contains a *Developer's Reference Guide* that details the use of all commands. Also available for $55 is an *Advanced Technical Guide* (70 pages) that provides details on file structures and special programming features. The *User's Guide* provides examples of the systems capabilities, and the *Developer's Reference Guide* indexes each command.
User interface. Metafile provides a menu-driven mode to communicate with the user, an interactive command

mode, and a structured programming language. A command is available to create frames (windows) so only a portion of the screen is active. Another command allows a menu selection to be returned in a reserved variable.
Help facilities. If an incomplete command is entered, Metafile automatically provides completion options via pull-down menus. A status line displays pertinent information about the active data file and commands. Pressing the help key during data input provides all validation information about the data item.
File capacities. The software allows 65KB records per file (each record with a maximum length of 1,000 bytes), 250 fields per record, and a maximum of 235 bytes for each field. The maximum number of active files allowed is 5, and the maximum file size allowed is 8 million characters. One text file can be active with a maximum of 250 characters per line.
Field types and capacities. Alphanumeric: 235 characters; numeric: 20 digits (only 16 for sorting or key purposes); and date: 7 or 9 characters with a DDMMMYY or DDMMMYYYY format. Date values are restricted between 01JAN1776 and 31DEC9999.
Data entry. Data validity checking via the data dictionary includes default values, multiple ranges, translation of coded input, defined input format, and defined output format. Validity checking is possible only on interactive input, and validity checks can be made screen dependent.
Applications development facilities. Turnkey systems development is supported through programming. Looping control is possible using IF, WHERE, WHILE, and FOR loops; loops and procedures can be nested to 22 deep. Parameter passing to procedures is possible via PASSED() and RETURNED(). Arrays are supported for variables and data items. Screen frame sizing, automatic menu option retrieval, and full text control, including animation and sound, are available. The text editor allows immediate execution of selected commands.
Security. Procedure files can be encrypted. Session ID (password) is available via a special variable for program checking.
Access to system facilities. Metafile provides access to external .COM files through the command line. External .BAT, .EXE, and .COM files can be accessed via an assembly language program provided in the *User's Guide*.
Query and sorting. Queries are created by qualifying records that meet a logical condition. Additional qualifications can be specified to provide additional subsets. Queries are generated either by pull-down menus or by interactive command mode. Sorting is on multiple keys in either ascending or descending order with a maximum key length of 250 characters. Sorting is not permanent and is only done on the currently qualified records.
Reporting. Columnar reports that provide totaling, averaging, and/or counts are generated with either a single command or a menu sequence. Report files can be created that allow Metafile commands to be embedded in them. Thus, complex reports are possible if looping and accumulation commands are included in the body of the report.
Utilities. Standard file handling routines erase, rename, and copy files. Text files are automatically backed up. Data entry can be set so that updating is not automatic, and the update of records is under program control.
Data compatibility. Metafile can import or export data only in SDF format.
Distribution. Metafile is distributed via a direct sales staff with offices in Chicago, IL, Minneapolis, MN, Philadelphia, PA, Rochester, MN, and Columbus, OH. More than 5,000 copies of Metafile have been sold.
Price. $995; demo version, $25; Lotus Interface, $40; *Advanced Technical Guide*, $55; Utilities, $60; Tabulate, $95; Metacom Communications, $125; LAN toolkit, $195; RUNTIME $795; RUNTIMEplus, $295.
Support. Telephone support, a newsletter called *Metafile INK*, classes, and an applications catalog are provided by Metafile Information Systems, Inc.
—V. Joseph Bowman

Metafile can be used with any local area network that supports DOS 3.1 function calls. Metafile does not provide any automatic locking capabilities, and the developer must provide the correct code as part of the application. Metafile directly uses the .COM files provided by LANs for locking and unlocking software. These files are indicated in the start-up statement and then are directly usable by the procedures; parameters are available through the RETURNED function if the results are returned in the standard location for parameter passing in .COM files. New images of files that may have been created by another user are obtained by issuing the command REFRESH.

END-USER FACTORS

Metafile's end-user interface, the Assistant, is menu driven and provides access to almost all functions of Metafile. The Assistant is available to the user by pressing the attention key or by partially completing a command. If the command requires field names, they are presented in list form for selection. The same is true for selecting data files or text files. The developer can customize Metafile by providing only a subset of commands to the user. This is accomplished using ELIMINATE COMMAND <command name>, which eliminates the command from Metafile and therefore should be performed only on copies of the program.

The IBM keyboard is not used effectively in Metafile. The function keys are ignored and the special function keys of Metafile are mapped into somewhat obscure key combinations on the keyboard— for example, help (Ctrl-L), insert record (Ctrl-F), frame left (Ctrl-T), frame right (Ctrl-Y), next record (Tab), and previous record (Backspace). A function keyboard layout card and key stickers are provided to aid in the appropriate use of keys.

Metafile supports full-screen data entry. As mentioned earlier, because screens are processed in the text area they can consist of multiple pages. In the text area, the cursor key pad provides the end user with easy movement from field to field and page to page. Because input is in the order specified during the creation of the screen, the developer can place input fields in whatever sequence that is desired. The screen function also allows data substitution, so fields that are calculated based on other input fields can be displayed on the screen as long as their sequence is after the fields that are required for the calculation.

One of the special features of screen handling is that the user can define frames that provide access to only a portion of the screen. All functions that use the text area, including screens and menus, are placed in the frame as if it were a mini screen. The commands SIZE 20,10 and AT 15,5 would define the active screen area as a frame 10 rows by 20 columns with the upper left-hand corner of the frame at row 5, column 15 of the screen. Other areas of the screen are untouched, and any cursor controls operate only in this frame. This allows for multiple page instructions to be presented on a portion of a screen or to simulate a windowing menu selection scheme.

The menu option discussed earlier is accessed by the SELECT command, which has three parameter options that provide added flexibility to the menu selection. One setting allows keyed data entry in addition to the specified menu options. The second alternative allows keyed-in data that must match one of the menu options. The third choice allows only the menu options displayed to be selected and returned in the OPTION variable. This feature was used in the *PC Tech Journal* sample editorial database to make department selection by menu and also to provide correct in-

put of state abbreviations. (For a complete description of the sample application, see "Sample Application Specifications," August 1985, p. 48. The article also is available for downloading on PCTECHline.) In the former case no keyed entry was allowed (see photo 2); in the latter, keyed entry was allowed as long as it matched the menu options.

Reverse video can be switched on or off via the SHADE command; only gray on blue or blue on gray is available with color monitors. Metafile has a graphics mode, but it displays only those characters with ASCII codes less than 128; thus, it does not provide any access to the line-drawing characters.

QUERY LANGUAGE

Queries are built by qualifying records in the currently active data file. No high-level query language exists to provide query capabilities; however, the ASSIST command allows for qualifying records via the use of menu selections, thus providing field names, operators, and connectors. Once the appropriate records are qualified, these records are available for display using ITEMIZE for one record at a time, LIST for a columnar report, which may be specified through the Assistant, or by using a report form. If data must be arranged in an order other than physical record sequence, a sort must be performed. Queries involving multiple files cannot be created directly and must be programmed, because Metafile provides no way of relating files.

Importing and exporting of data in non-Metafile files is limited to SDF format. In order to import data, the foreign SDF file must be renamed with a .DAT extension. Then a description file (.DES) is created, which has the same field names as the file to which the data are being imported. The position variable in the description of the foreign file is the fixed character position where that field name begins. Fields that are not to be converted should not be described. Because the .DES file applies to the foreign file and does not have the standard interpretation of the position variable, it must not be used with any Metafile data file.

Importation is accomplished using the following command:

CONVERT D <filename> F.

The *D* specifies that the active Metafile data file is to be the destination, and the *F* means that the source file has fixed-length records. Exporting requires the same process except that the parameter *D* is changed to *S* for source. Changing the *F* to *V* specifies that the foreign data record is variable length. This applies only to the length of the record; the fields to be converted should be fixed length and should begin in a fixed position.

The data file to be imported must be terminated with both end-of-record and end-of-file marks. This sequence, which is not always created when an SDF file is created, is most easily accomplished using the DOS COPY command with the parameter /A specified. CONVERT also can be used to output data from one Metafile data file to another. In the process, the order of fields can be rearranged.

The use of arrays provides another method of importing data from delimited files if their maximum line length is less than 235 characters. After renaming the delimited file to a .DAT extension and adding the end-of-file mark, the user can define the associated .DES file with a single character field 235 characters long. A temporary destination Metafile data file is also defined with the same description. CONVERT is used to convert the delimited file into a Metafile data file. At this point the single field, say DATAIN, of this file contains an exact replica of the delimited file record. Because array elements in Meta-

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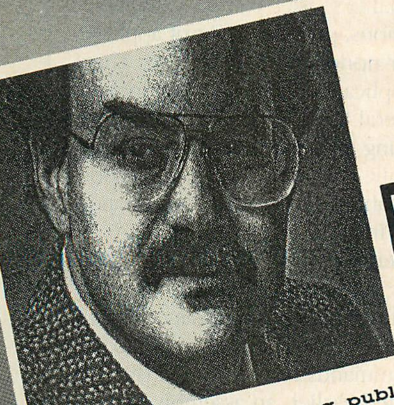

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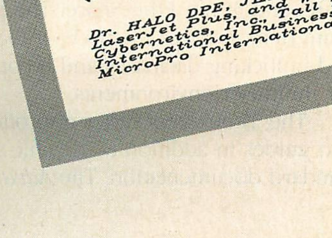

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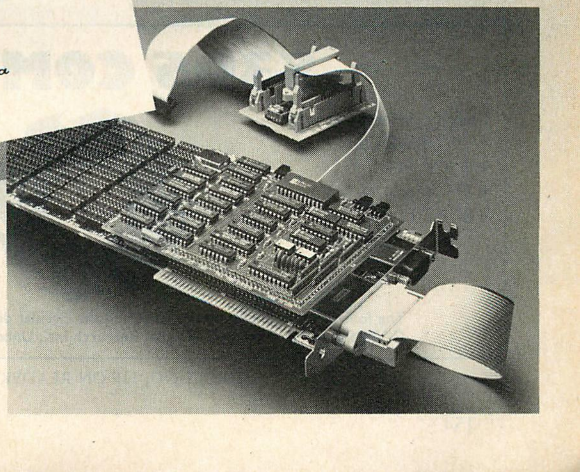

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file are separated by delimiters, one of which is the comma, assignments can be made directly by setting field1 = DATAIN(1), field2 = DATAIN(2), etc.

EXISTING APPLICATIONS

Metafile offers two options for distributing applications. RUNTIME ($795) is purchased once and may be distributed freely. RUNTIMEplus ($295) includes some word-processing features so the end user can modify the application. One copy must be bought for each distributed copy of the application.

The only application included with the Metafile package is the demonstration suite. Because the demonstration is written in Metafile procedures, it provides some programming examples for learning Metafile.

Metafile's sister company, Metafile Applications, provides a set of applications for nonprofit organizations. Third-party applications are available, including general business packages, such as accounting and order entry, and industry-specific packages. These applications are available from Metafile Information Systems in a 128-page catalogue.

Metafile provides a series of productivity tools in its Timesavers series. The Utilities package consists of three programs. SUBMIT allows access to DOS commands from Metafile. (As mentioned earlier, an assembly language listing of this program is provided in the *User's Guide.*) DOSTIME displays the current system time and KEYLOCKS displays the status of CapsLock or NumLock at any specified location on the screen.

Tabulate is a Metafile procedure, supporting screens and reports for generating cross tabulations or spreadsheet summary of Metafile data. This is a sophisticated procedure that combines data from both primary and secondary data files using the KEY feature. Counts, sums, and percents are provided.

Metacom is a program that can be used to operate an intelligent modem within Metafile. It builds a database of phone numbers along with the communications protocol to be established when dialing. This program requires access to the DOS programs COMMAND, MODE, and BASICA.

The LAN Toolkit provides utilities for interfacing with PCnet, Novell NetWare, and 3Com EtherShare. The program demonstrates methods of locking and unlocking databases and records for multiuser environments.

The Timesavers series also offers two guides in addition to Metafile's standard documentation. The *Advanced*

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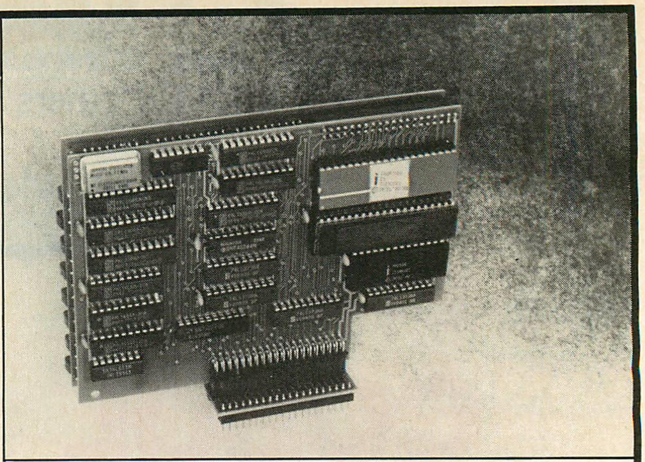

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Technical Guide provides details on the structures of data and text files, arrays, and communications protocols. Another publication is *Lotus Interface*, which explains how to write SDF files using Lotus 1-2-3 and then how to import them into Metafile and vice versa.

Metafile's standard documentation comes in three volumes. The first consists of the *Installation Guide* and a *Quick Orientation Guide*. The *Installation Guide* provides a short form for experienced computer users and a long form for novices. It discusses Metafile's configuration options, capacities, requirements, and limits, and it contains trouble-shooting guides. The *Quick Orientation Guide* offers a brief demonstration of features. The presentation is made through Metafile's end-user interface and is easy to follow.

Volume 2 contains the 14-chapter *User's Guide*. Each chapter presents a particular topic that introduces a new set of reserved words. The first several chapters discuss how to get into and out of Metafile and describe how the data and text management techniques interact. Succeeding chapters provide information on file utilities, screen generation, procedures, functions and variables, menus, report formats, special applications development facilities, communications and networking, and use of non-Metafile programs. Three appendices are provided: one describes the Assistant; one lists error messages, including a description of probable cause, correcting action if any, and a rating of the seriousness of the message; and the third lists special considerations in using some of the features.

The third volume is the *Developer's Reference Guide*, which lists reserved words alphabetically and gives the purpose, syntax, explanation, restrictions, related commands, and examples. Tabs break the alphabet into six ranges, and each reserved word is clearly printed at the side of each page. This allows easy access to the commands with the "manual lexicographic search technique"—that is, thumbing through the pages.

SAMPLE APPLICATION

The development of *PC Tech Journal's* editorial inventory system highlighted many strengths and weaknesses of the Metafile product. Metafile's strengths were in the building of user interfaces such as screens and reports, while data manipulation tended to require more programming effort because of the lack of relationships and indexing.

The first stumbling block encountered was in converting the data from the delimited format files to a Metafile structure. Because Metafile can import only from SDF files, this seemed at first to require changing the delimited files to SDF format. However, the lengths of the delimited records were less than 235 characters, so a program was written to convert the data into a single field record; then the array capabilities were used to break out each delimited field and place its value in the appropriate field of the target database. For each database this meant defining two descriptions, one for the delimited file and one for the imported Metafile equivalent. Because these descriptions contained only one field, they could all be copied once one had been defined. Data were imported into the single field IN using the CONVERT command and put into the appropriate database by treating IN as an array. For example, in the author database the command was:

```
SET
   LAST_NAME:IN(1),FIRST_NAME:IN(2)...
```

Metafile defines a comma as a delimiter between array elements and strips any quotation marks, thereby mapping the elements appropriately from the delimited Metafile record.

Another alternative was to write either a dBASE or BASIC program and rewrite the date to SDF format. In this case the description file (.DES) of the SDF file had to be set so that the position value was equivalent to the starting character of each field.

Once the files were in Metafile format, several of the advantages of the development features of Metafile using an active text area became immediately apparent. The ability to select a block of code and execute it without leaving the editor was a tremendous time saver in both developing accurate code and debugging. A second interactive development feature that was of help in screen development and report formatting was the ability to see the text with real data by pressing the evaluate key (Ctrl-E). A major annoyance in both code development and the interactive mode was that Metafile requires all commands to be written in uppercase. A portion of the debugging process was consumed in correcting "Unknown Command" errors that were the result of failure to toggle the CapsLock key on.

Arrays should be given full consideration when designing Metafile databases. In the sample application, defining the coauthor field as character with maximum length (235) allows multiple coauthors to be handled simply, as long as the total length of the coauthor

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by Cary Harwin

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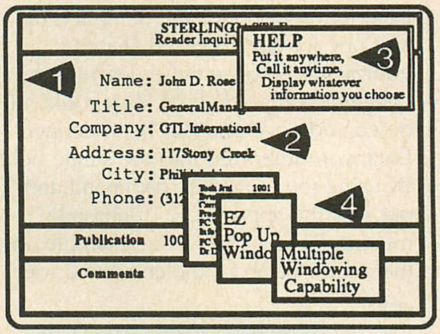

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names is less than the maximum. The last name of the first coauthor is COAUTHOR(1,1), and the first name is COAUTHOR(1,2). The full name can be obtained by COAUTHOR(1). This produces a separating comma between the last and first names; however, a trailing comma at the end is also included and must be stripped for correct reporting. Another reason for using arrays is that Metafile requires keys to be a single field. Thus, in the Issue data file another field was defined as ISSUE_KEY with the components:

```
ISSUE_KEY(1) = VOLUME
ISSUE_KEY(2) = NUMBER
```

Determining the deadline for an issue was found by pointing on the key ISSUE_KEY. The volume and number were automatically displayed as year and month using the translate option in the database description.

One of the sample application tasks is to develop an input screen for article information. Several functions inherent to Metafile data field definitions were used to require certain input, validate ranges, and define output formats. The menu feature, along with defining and sizing frames, was used to guarantee accuracy of the Category, Department, and State fields. The result of the sequence of commands

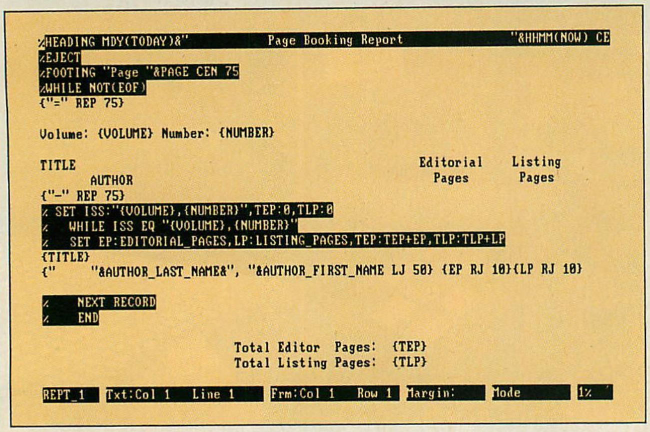
```
SIZE 20,10
AT 50,8
SHADE 1
SELECT CATEGORY.MNU, SUPPRESS
SET CATEGORY:OPTION
```

produces the screen shown in photo 2. The SIZE, AT, and SHADE commands set the frame size, location, and color. The SUPPRESS option causes the user to select one of the four options presented. The SET command assigns the value in the system variable OPTION, which holds the selection, to the data field. This same technique was used for the Department field.

Input of the State field used SELECT STATE.MNU, MATCH. The MATCH option allows the user either to select the desired state or type it in. If typed in, data are validated against the allowable menu options and an error returned if no match occurs. This menu was multipaged, illustrating the full use of the cursor keys in the text area.

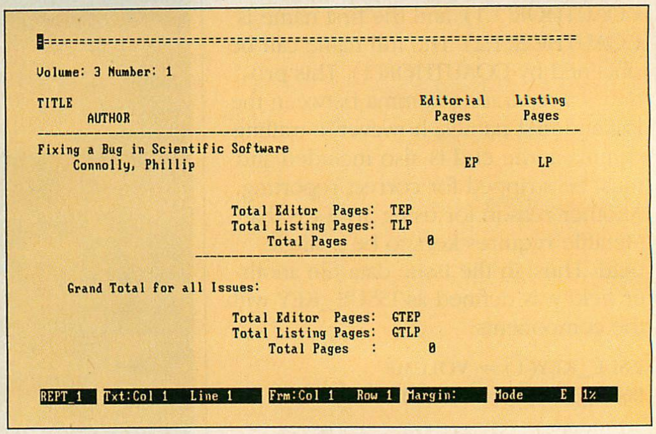
Producing reports in the sample application met with mixed success. The first report was columnar and provided booking information on a particular magazine issue. If the data to be output had fit on a single line, LIST could have been used to supply totals, aver-

PHOTO 3: *Commands Embedded within Report*



```
%HEADING MDY(TODAY)&"              Page Booking Report                 "&HHMM(NOW) CE
%EJECT
%FOOTING "Page "&PAGE CEN 75
%WHILE NOT(EOF)
{"=" REP 75}

Volume: {VOLUME} Number: {NUMBER}

TITLE                                                   Editorial    Listing
     AUTHOR                                               Pages       Pages
{"-" REP 75}
% SET ISS:"{VOLUME},{NUMBER}",TEP:0,TLP:0
%   WHILE ISS EQ "{VOLUME},{NUMBER}"
%   SET EP:EDITORIAL_PAGES,LP:LISTING_PAGES,TEP:TEP+EP,TLP:TLP+LP
{TITLE}
{"     "&AUTHOR_LAST_NAME&", "&AUTHOR_FIRST_NAME LJ 50} {EP RJ 10}{LP RJ 10}

%    NEXT RECORD
%    END

                        Total Editor  Pages:  {TEP}
                        Total Listing Pages:  {TLP}

REPT_1  Txt:Col 1   Line 1   Frm:Col 1   Row 1  Margin:   Mode      1%
```

PHOTO 4: *Evaluated Report Format*



```
==========================================================================

Volume: 3 Number: 1

TITLE                                                   Editorial    Listing
     AUTHOR                                               Pages       Pages
--------------------------------------------------------------------------
Fixing a Bug in Scientific Software
     Connolly, Phillip                                     EP          LP


                        Total Editor  Pages:  TEP
                        Total Listing Pages:  TLP
                             Total Pages   :       0
                    ------------------------------

    Grand Total for all Issues:

                        Total Editor  Pages:  GTEP
                        Total Listing Pages:  GTLP
                             Total Pages   :       0

REPT_1  Txt:Col 1   Line 1   Frm:Col 1   Row 1  Margin:   Mode    E  1%
```

As photo 3 shows, any Metafile command can be included in a report form so that looping and value assignments can take place. While the report is being developed in the text area, pressing Ctrl-E will display the evaluated layout as shown in photo 4.

ages, and counts. However, automatic word wrapping for a field is not provided, resulting in the truncation of data if they exceed the allowable print area. Consequently, a report form had to be generated, but it was easy because of the ability to embed Metafile commands within the report. Photo 3 shows the report format with the embedded commands as it was developed in the text area. Pressing Ctrl-E reveals the evaluated form shown in photo 4.

The next report was a label print of all authors and coauthors for a particular issue. These labels were assumed to be multi-up; therefore, a large amount of programming was required because Metafile does not have a means of relating files. First, all articles for this issue were qualified and the author and coauthor names collected and written to a temporary file. Then, all authors not in the set to be printed had to be eliminated from the Author data file with the DISQUALIFY command. This meant one complete pass had to be made through the Author file, pointing into the temporary file and disqualifying the Author record if a match was not found. Reading the temporary file record-by-record and searching the Author file would have meant a pass through the 900-record Author file for each author in the temporary file.

The third report, which produced information on articles written by

authors was simple because only the Article file had to be processed.

The sample application contained a series of ad hoc queries that emphasize the record qualification method used by Metafile. Every query has two parts: record qualification and data extraction. To illustrate, the ad hoc inquiry for finding all titles in an issue consisted of

```
FIND VOLUME = 3 AND NUMBER = 4
LIST TITLE
```

The first command qualifies the records; the second performs the task.

Because Metafile commands usually return single valued quantities for variable storage, the record qualification approach makes Metafile perform quicker than expected after simple analysis of the code if the set of qualified records is small. This was illustrated in the query that requested the average payment per page. The data extraction commands after qualification were:

```
SET A:SUM(EDITORIAL_PAGES
   +LISTING_PAGES)
SET B:SUM(PAYMENT+BONUS)
WRITE B/A
```

At first glance this appears to be extremely inefficient because SUM must be issued twice. However, for the specified query, the number of qualified records was six so that the two SUM operations directly addressed a total of only 12 records. If the query had been for all issues, the same command would have had to pass the entire database (360 records) twice. In this case a more efficient method might be to use LIST's averaging capability. However, LIST has no summary capability, so all qualifying items would be listed before the desired result could be found.

One other query illustrated this dichotomy of Metafile's strengths and weaknesses for small changes in conditions. The requirement to find all articles received past the deadline for a particular issue was straightforward; it called for pointing to the Issue file in order to find the deadline, qualifying the records in the Article database, and then extracting the information. The commands required were:

```
IN ISSUE
POINT ISSUE_KEY = "3,4,"
SET DEAD:DEADLINE
IN ARTICLE
FIND VOLUME = 3 AND NUMBER = 4
  AND DATE_RECEIVED > DEAD
LIST TITLE;DATE_RECEIVED
```

If this simple query were changed to include multiple issues, such as a single volume, a small program would have to be written. This is due to the lack of any relational capability between files in Metafile, which would prevent automatic positioning of the Issue file to the correct record.

Metafile provides easy query capabilities when working on a single file or when requiring information from a single record in another file. It also performs well when the qualified records are a small subset of the total database, because repeated queries address only the qualified records.

BENCHMARK RESULTS

The same five benchmarks that have been run on other data managers in this series were run on Metafile under the same environment. The results are shown in table 1. In relation to previously reviewed data managers, Metafile was one of the slowest on benchmark 3; it was average on benchmark 5; and performed well above average in benchmarks 2 and 4. These two benchmarks in which Metafile was one of the top tested so far used Metafile's generation of temporary pointer files.

Benchmark 1 was a special case for Metafile because the program does not have direct import capabilities for delimited formats. The benchmark was run under two programs. One used the

TABLE 1: *Benchmark Results*

BENCHMARK TASK	TIME (secs)
Add 900 records to an empty database table	
From a delimited file	444
From an SDF format file	83
Index table on two fields (7 bytes)	20
Document and tally codes from one column	103
Mass change of one column (28 rows of 900)	9
Extract selected records to create a text file	9

When compared with data managers previously reviewed in this series, Metafile performed well above average indexing and changing records, and turned out to be one of the slowest on line output of tallied codes.

array capability of Metafile discussed earlier to import the data directly from the delimited format. This required an intermediate file and then the placement of each field in each record in the target data file; thus, it had one of the worst performances of any product reviewed to date. The benchmark was rerun with the data in SDF format. Here Metafile performed well above average when compared against other data managers; however, because the other data managers were importing using delimited format and the time required to restructure the input file into SDF format is not measured, no direct conclusions can be drawn.

Benchmark 2 required creation of an index on state and zip code. This meant using SORT to create the temporary index. This does not physically sort the records, but instead builds the equivalent of an index file. This file is not updated with new information, however, and will be lost with any subsequent SORT, FIND, or discontinued use of the file.

The poor results of Benchmark 3 seem to indicate a weakness in Metafile's interaction with the screen using program commands. This test required counting the occurrence of each state code in the author file. The required information could have been easily produced using the LIST command:

```
LIST STATE,,,CNT,1,Y
```

CNT means a count on breaks is to be produced, the 1 indicates that this is the first-level break, and the *Y* signifies that printing of STATE should be suppressed if its value is the same as the last line. This method was substantially slower than the benchmark program, which counted while skipping through all records in state sequence. Because the LIST command was a single command that had to be parsed only once, it should have performed rapidly. However, with no summary capability, it required printing a line to the screen for each record even though multiple occurrences of state were suppressed in printing. The actual as well as visible slowness of this operation led to the conclusion of inefficient screen handling for line output.

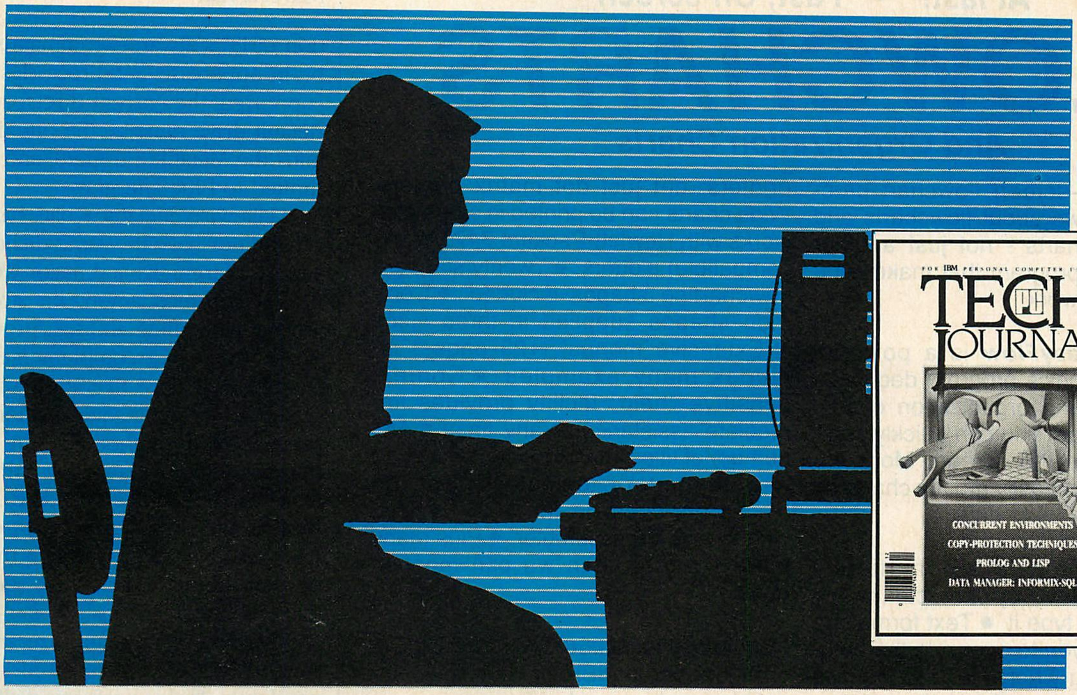
Benchmark 4 tested the change of the state abbreviation CO to CL. The test made use of the fact that the data were provided in state sequence as a result of benchmark 2. The LOCATE command was used to position the data to the first occurrence of STATE = "CO", and a WHILE loop changed the succeeding records.

Because exporting to delimited format is not supported in Metafile, benchmark 5 required writing a string sequence to an intermediate file in delimited format. This was then converted to a foreign file.

STRENGTHS AND WEAKNESSES

The real strength of Metafile lies in its ability to allow the developer to build sophisticated user interfaces with minimal effort. While several other data managers provide good user interfaces in the interactive mode, Metafile allows the developer to produce custom code that provides the same level of sophisticated user interface. In fact, the entire Metafile ASSIST function could be built by a developer using the Metafile command structure. Metafile provides the developer with power far beyond what many data managers currently offer, including capabilities to define frames that automatically keep all screen I/O within this frame, to allow menus to be defined and their selected option made available to the program, and to treat text as a special type of data file with equivalent manipulation.

Unfortunately, other aspects of Metafile temper these outstanding features. Some of the problems with Metafile are simple annoyances that indicate Metafile has not kept up with the evolu-



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tion of PC software—commands must be in uppercase, subdirectories are not supported, the current directory of the default drive must be the one that contains the Metafile program, and color is limited to blue and gray.

Likewise, Metafile's data handling capabilities have the same dichotomy of superior strengths and major weaknesses. Foremost among the strengths are array handling and text processing. These are further complemented by a series of functions that allow simple qualification and disqualification of records. On the other side, the restriction to the use of keys only for exact matches, the inability to relate different files, and the restricted import capabilities make Metafile a program that must be evaluated in terms of the specific job that is to be accomplished.

Metafile is well suited to an application requiring the use of files independently. It also performs well in environments where only single records are required from secondary data files and the access is by a single field. More sophisticated data structures can be handled in Metafile but the lack of relations makes the programming effort substantially more complicated.

Metafile Information Systems is aware of these shortcomings and has announced version 9 of the product. This version was not available for testing but should be on the market by the time this review appears. Metafile claims this version will provide the following enhancements:

- Expanded capacity will allow 2,000 characters per record, procedure nesting to 40 deep, physical data files to 16MB, and eight active data files.
- Performance improvements in the upcoming version will include the ability to change an existing record rather than creating a new record, reduced I/O time, support of duplicate key values, expansion of POINT to include <,<=,>,>=, and navigation through the records via key values.
- Requirements will be for 256KB, serial adapter, and DOS 2.1 and higher.

This new version appears to alleviate many shortcomings of the current product, especially with the increased use of keys for accessing data and the allowance for multiple occurrences. Upgrades are to be available for $195, and version 9 is supposed to be 100-percent compatible with version 8.

V. Joseph Bowman, Ph.D., owns Bowman Associates, specializing in information resource planning. He is treasurer of PC Professionals Association of Southern California.

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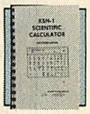

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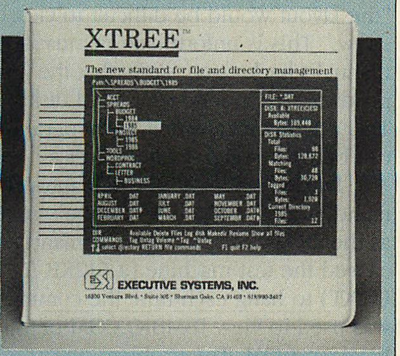

CIRCLE 362 ON READER SERVICE CARD

Many DOS directory managers are available, but no single such utility has become standard equipment for the PC user. XTREE from Executive Systems may be a candidate for such status. XTREE is appealing to the beginner because it is easier to learn than DOS. Veteran users of DOS will find it useful as well—it is more powerful and better designed than COMMAND.COM.

Unlike the directory enhancer WindowDOS from Software of the Future (see Product Watch, March 1986, p. 179), XTREE is not a terminate-and-stay-resident program; while WindowDOS can be invoked from within an application, XTREE cannot. However, XTREE includes hard disk organizing commands that WindowDOS lacks, most notably a command that can be used to remove a directory.

To enter XTREE, the user executes XTREE.EXE (a file of about 43KB) from the DOS command line. The user then is able to execute other programs from inside XTREE. The manual states that XTREE requires 192KB of RAM, but it reduces the memory available to programs executed from within it by only about 60KB. XTREE remains fully functional when working with up to 2,500 files stored in 180 subdirectories.

XTREE divides the screen into five windows. The three smaller windows identify the currently selected disk and display file and directory sizes. The largest window shows the directory structure of the specified disk in a tree structure. Each node of the tree identifies the name of a directory.

The user selects a current directory by moving a reverse-video bar through the tree with the cursor-control keys. The files window lists the files contained in the specified directory. The speed with which XTREE lists files and directories is impressive; the program responds almost instantly. This is possible because XTREE's file searches are not disk-bound—XTREE retains a copy of the current volume's directories in RAM. XTREE can limit the display to a set of files defined using ordinary DOS conventions, including the DOS wild cards (? and *). XTREE does not limit the user to directory-by-directory file searching; it features a convenient show all mode that lists all matching files, regardless of their directory.

File searching is only a minor component of XTREE's suite of abilities. The program also lets the user create, rename, and delete directories; copy, delete, and rename files; and move files between directories. In addition, the program can copy a group of files onto multiple diskettes when the size of the files exceeds 360KB.

All processes that are possible in COMMAND.COM are also possible—and more convenient—in XTREE. In addition, XTREE provides the user with features that are not found in COMMAND.COM. For example, XTREE's replacement for the TYPE command is a built-in read-only editor that supports two-directional paging, scrolling, and ten position markers. XTREE can sort its file lists alphabetically by root or extension, by file size, or by date. An XTREE user can search subdirectories or stacks of diskettes quickly for a particular file, collect a group of scattered files and put them in one subdirectory, set and reset archive bits, and change directory names and volume labels.

The product offers several convenient methods for tagging files, then manipulating them as a group—it even can select files of a particular DOS attribute (for example, hidden or read-only). The user can assign any set of attributes to any file or remove any existing attributes from a file.

An install program can be used to customize XTREE's colors. In addition, this program allows the user to choose between a BIOS call to interrupt 10H or a direct call to the display adapter's memory. In this way, XTREE should run on machines that are IBM BIOS compatible but do not map display memory as IBM does, such as the Tandy 2000 and the TI Professional.

The XTREE program has no real bugs—only minor annoyances. It loses track of the currently marked file when it expands its file window, and it does not always restore the cursor to its original size upon exit. However, XTREE's file-copying function, unlike the DOS function, preserves the read-only attribute. (XTREE's manual does not mention this.) Also unlike DOS, XTREE does not accept a volume label that matches the label of an existing directory or file name. XTREE's EXEC function reloads COMMAND.COM for each program name typed by the user.

XTREE lacks some minor features that users might find convenient. It would be helpful, for example, to tag files of a specified date, to move a subdirectory under a different directory node, to compare files more easily than is possible with the DOS COMP com-

mand, to access the DOS FIND command, to see the actual disk space occupied by files (as opposed to the number of bytes they contain), to manipulate the two unused file attribute bits, and to see files and sizes in all subdirectories under a particular directory.

Much thought and practice is required before the novice is able to use all of XTREE's features routinely. However, anyone using DOS and a hard disk should find mastering this directory manager well worth the effort.

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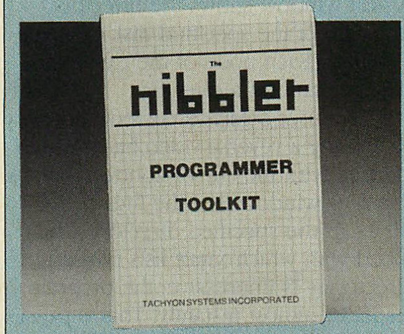


CIRCLE 361 ON READER SERVICE CARD

Billed as a programmer's toolkit, version 2.0 of The Nibbler from Tachyon Systems, Inc. offers several disk utility operations. The product's windowed screens are nicely done, and the program loads and operates quickly. On-line help messages are provided for almost every operation. Despite these amenities, however, Tachyon would do well to put this bug-ridden utility back on the drawing board.

The Nibbler's operations can be selected by pressing function keys. Tachyon notes in the manual that redefining the function keys can prevent The Nibbler from operating correctly. Utilities such as SideKick and SuperKey from Borland International or RoseSoft's ProKey can be used with The Nibbler only after careful consideration is given to key redefinitions.

The Nibbler can display sorted disk directories, copy files, change bytes in files, recover deleted files, and collect memory and disk information into 512-byte memory buffers that eventually are written to disk. The Nibbler also allows the user to specify track, head, and sector numbers to read and write disk sectors directly.

The Nibbler's manual, which does not include an index, lists among the product's operations the ability to label disks or to change existing labels as well as the ability to change the status of files. To accomplish these tasks, however, the user first must read the appropriate disk sector into memory, edit the appropriate bytes, and write the changed data back to disk. Despite the suggestion included in the manual, no single command is available to perform this operation, as is the case in some utility packages, including Software of the Future's WindowDOS.

Perhaps the most serious problem with this program is the File Map command, which does not work on hard disks because, according to the manual, "the layout would be difficult to clearly show." This is unfortunate because the manual's back cover states that the product can operate *on* a hard disk. This actually means that the program can be operated *from* a hard disk.

During testing, the File Map command, which showed up on the screen as the DOS Diskette Map command, caused the test machine (a 512KB PC/XT) to hang each time the command was used to view IBMBIO.COM or IBMDOS.COM. The problem occurred when running either the master disk or a direct DISKCOPY of the master. According to Tachyon, this effect is intentional—the IBMBIO.COM and IBMDOS.COM files have been emptied to ensure that these parts of the copyrighted DOS software cannot be distributed by the user. This effect is limited to these files on the master diskette and could not be duplicated with other files on other disks. Such behavior by a software product is unacceptable.

The Nibbler's editor is well written. With it the user can edit file or memory data as either hexadecimal bytes or ASCII characters. The user also can search through memory or disk data for strings. Edited bytes are redisplayed in bright underlined characters that clearly stand out on display. In addition, the user can copy memory into disk files in an attempt to recover data that have not been erased from memory.

Unfortunately, The Nibbler's other program operations are not so well designed. On a hard disk that contains many subdirectories, the program does not allow the user to step from direc-

tory to directory as is possible with the DOS CD (or CHDIR) command. Instead, the user must select the desired drive, then position a reverse-video cursor over one of the displayed subdirectories (the program always displays all of the subdirectories contained on a disk). The program completely ignores the tree-like structure of a typical hard disk organized with directories inside of other directories. After displaying a subdirectory, the user presses Escape to return to the main prompt where another drive must be selected and the cursor repositioned over the desired directory. This feature is poorly thought out and awkward.

An encrypt/decrypt operation is provided with The Nibbler to scramble and unscramble file data, thus protecting sensitive information. Only by typing the correct password can the original data be recovered. The manual states that the program does not use the Data Encryption Standard (DES), but it offers no information about the technique that actually is used.

The Nibbler can read p-System disks in UCSD Pascal format; it does not recognize, however, the other most popular p-System directory formats: Network Consulting's 800-block and Pecan Software System's 720-block configurations. When the disk drive of the review machine was reconfigured to access tracks as cylinders, The Nibbler was able to read a nonstandard Pecan-formatted 640-block disk directory. However, it still was not able to read or transfer file data. It displayed and copied several p-System files as though they contained only F6H bytes, even though the contents of those files were verifiably intact.

The Nibbler is a rather noisy program. Error messages are accompanied by a beeping sound, as is the case with a press of the Escape key.

Technical support from Tachyon is not always reliable. Phone calls to the company during the time of the review were not always answered as promptly as had been promised.

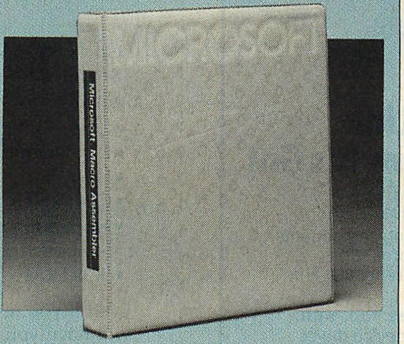
The lack of an index in the manual, the ambiguous documentation, the quirk of the distribution diskette, the inability to read popular p-System disk formats, the unnecessary beeping, and the poor technical support all detract from what was otherwise a good idea. Its well-done screens and the numerous on-line help messages are a promising start, but The Nibbler needs additional development work.

—TOM SWAN

MACRO ASSEMBLER VERSION 4.0

Microsoft Corporation
16011 N.E. 36th Way, Redmond, WA 98073-9717
800/426-9400

PRICE: $150



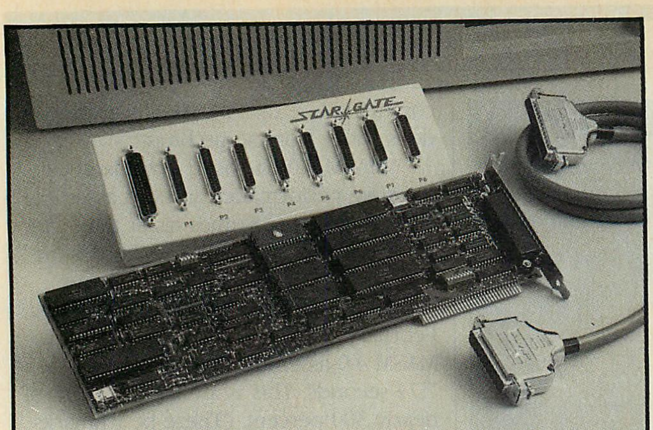
CIRCLE 365 ON READER SERVICE CARD

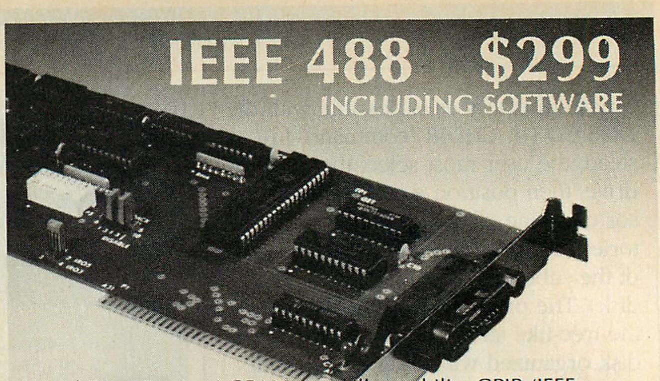
Microsoft's latest release of its macro assembler (MASM version 4.0) is intended to be 100-percent compatible with both the IBM macro assembler version 2.0 and the Microsoft macro assembler version 3.01 (see "Same Language, New Architecture," Ted Mirecki, October 1985, p. 48). It features several new commands as well as many new command-line options. However, it does suffer from some bugs.

MASM 4.0 has been optimized to improve performance and can assemble code two to three times faster than prior releases. MASM 3.0 assembles the 480-line program PACKDIR.ASM (see "Dipping into Directories," Ted Mirecki, February 1985, p. 67) in 20.15 seconds; MASM 4.0 assembles the same file in 7.74 seconds. This is an improvement of nearly 300 percent. (These benchmarks were run on a 6-MHz PC/AT with the assembly language program files on a RAM disk and the source file on a 360KB floppy disk.) The I/O buffers and macro text have been moved out of the symbol space, allowing the assembly of larger source files.

Another new feature of MASM version 4.0 is conditional error directives, which allow the user to check parameters, boundaries, and other assembly-time values. The directives generate an error if predefined conditions are not found to be true during the search. Several new exit codes have been added as well. These codes can be tested using the ERRORLEVEL batch command and the MAKE command.

MASM 4.0 includes a number of new command-line options:





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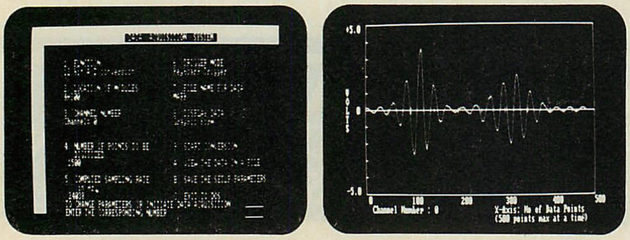
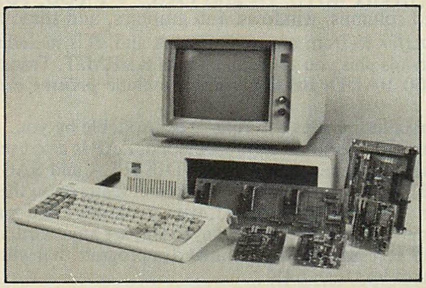
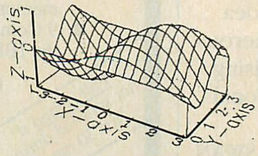






Z-axis
X-axis
Y-axis

- –**B nn** directs the assembler to adjust its file buffer size to **nn** bytes. This is one way MASM has improved performance—by assembling with a buffer that is larger than the source file, MASM must read the source file from disk only once.
- –C creates a cross-reference file with the base name of the source file and the extension .CRF. This option allows compatibility with XENIX.
- –L creates an assembly listing file with the base name of the source file and the extension .LST. This option also is provided to allow program compatibility with XENIX.
- –D symbol defines a symbol that can be used during assembly as if it had been defined in the source file. The specified symbol is defined as a null-text string and can be evaluated by the IFDEF and IFNDEF conditional-assembly directives.
- –I path sets the path by which the assembler will search for files specified with an INCLUDE directive. Up to ten search paths can be set. The order of the search is the order in which the paths are listed on the command line, then the current directory.
- –N suppresses generation of a symbol table in the listing file.
- –P can be used to search for impure code that can cause problems in 80286 protected virtual mode. (Code that moves data into memory using the CS: override prefix can cause problems in protected mode.) This option has no effect unless the .286p assembler directive was specified in the source file. When –P is in effect, error message 100 is generated if impure code is detected.
- –T (terse) suppresses all messages if no errors are encountered.
- –V (verbose) instructs MASM to display extra statistics after assembly.
- –Z displays the source lines that contain errors on the screen (without this option, only the error message is shown). Previous versions of MASM always displayed both the source line and the error message.

MASM 4.0 listing files now indicate the nest level of macros. Line numbers are right justified with leading zero suppression, and a time stamp and improved symbol table have been added.

- –O (octal) is not supported in the new release of MASM.

The new version of the macro assembler suffers from several bugs. For example, error messages sent to the console cannot be redirected to a disk file. In addition, if users assemble to NUL.LST or FILE.LST, "%OUT" messages to the console appear as they should; however, if users assemble to CON, the messages are suppressed. Finally, MASM 4.0, like its predecessors, does not parse the final END key word correctly unless it is followed by a carriage return/line feed.

Most assemblers feature the ability to redefine instructions and directive mnemonics by macros; MASM 4.0 does not support such redefinitions.

During testing, a problem with the listing file was noticed: the assembler directive, ASCIIZ DB "C:\",61 DUP (?), listed the source statement twice.

The format of the cross-reference utility, CREF, remains virtually unchanged in MASM 4.0. A date/time stamp has been added, and Microsoft claims that CREF now uses all available memory space, allowing production of larger cross-reference files.

LINK has two new command-line options: /E allows the user to pack executable files at link time, forming a smaller .EXE file that is able to load more quickly. During testing, a 15- to 20-percent reduction in .EXE file size was achieved. The second command-line option, /H, displays a list of linker options. Microsoft claims that LINK has been optimized to make the link process faster; however, no difference was detected during testing. LINK also features a number of new exit codes.

The LINK command in MASM 4.0 still relies on VM.TMF for a temporary work file, even though DOS 3.x provides a "Create unique file" option. LINK is unable to realize it is running under a more recent DOS release and fully use the available functions.

Several new command-line options have been added to the debugger SYMDEB. /K enables the break key as an interactive breakpoint key, and /N enables a nonmaskable interrupt service routine. (The documentation states that, "To use nonmaskable interrupts, your system must be equipped with the proper hardware." Proper hardware is a push-button switch that shorts I/O channel pins B1, which are ground, and A1, which are -I/O Channel Check.) /S enables screen flip and uses an additional 32KB of storage in which to preserve the screen image. **/commands** designates start-up commands executed immediately upon entering SYMDEB.

In addition, new SYMDEB commands have been added to MASM 4.0 as well. The exclamation point (!) is a

shell escape, used to load and run COMMAND.COM. If ! is followed by a DOS command, the system executes the command, then returns automatically to SYMDEB. The period (.) displays source lines when debugging high-level language programs (with the exception of MASM). ***comment** echoes **comment** to the display. The backslash (\) (screen swap) allows the user to view the screen display of the program that is being debugged. It requires use of the /S option when SYMDEB is started. **V address** displays high-level language source lines beginning at **address**. **Z symbol value** sets the address of **symbol** to **value**.

MASM's MAKE command has been enhanced greatly and now includes macro definitions and inference rules. Macros can be nested. The form of a macro definition is **name=value**; when **$(name)** is found in the description file, it is replaced with **value**.

Macro definitions either can be placed on the command line or embedded within the description file. When executed, MAKE searches the environment for **name**. For example, if the environment contains the equation PATH=C:\SOMEPATH\, then occurrences of $(PATH) in the description file are replaced with C:\SOMEPATH\.

MAKE features several special macros: **$***, **$@**, and **$****. **$*** means to substitute the base name portion of the target (without the extension); **$@** means to substitute the complete target name; and **$**** means to substitute the complete list of dependencies.

In MASM 4.0, MAKE also supports inference rules. An inference rule generalizes the traditional explicit MAKE target/dependent relationships into a rule. For example, a rule could be defined to specify that .ASM files be processed into .OBJ files by invoking MASM in a specified way. If a line appears in the MAKE file requesting that a target .OBJ file be produced from a dependent .ASM file *without* an explicit command on the subsequent line, the inference rule takes over and executes MASM in the specified way to produce the .OBJ file.

Inference rules can be placed in a file called TOOLS.INI on lines that are marked at the beginning with the tag **[make]**. If MAKE fails to find a dependency rule in the current file, it searches TOOLS.INI and applies any inference rules that it finds there.

MAKE includes several new command-line options. /D displays the last modification date of each file as the file is scanned. /I ignores exit codes that are returned by programs called by the MAKE description files. /N displays the commands that would have been executed by the description file without actually executing them. /S is used to execute in silent mode—that is, executed lines are not displayed.

MASM 4.0 offers two new utilities. EXEPACK performs the same function as the new /EXEPACK (/E) LINK option except that EXEPACK works on programs that already have been linked. EXEMOD displays the current status of the DOS program header and allows the user to alter the initial SP (stack pointer) and to set the minimum and maximum allocation values.

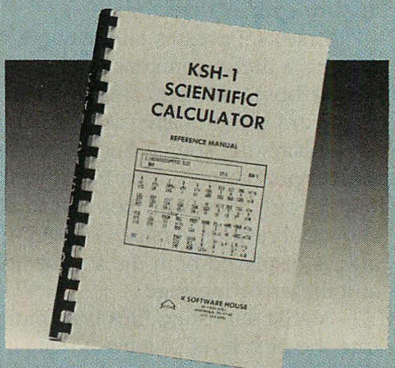
Overall, the documentation supplied with MASM 4.0 is impressive. However, a reference section was not included for the assembly language itself. The documentation for IBM's MASM 2.0 is far superior in this respect. Also, at least one error message that turned up during testing (in connection with LINK's /E command) was not documented. Perhaps the answer is to purchase two assemblers: the Microsoft product for the programs and the IBM product for the documentation.

—GUY QUEDENS

KSH-1 SCIENTIFIC CALCULATOR

K Software House
Route 2 Box 83B1, Unionville, TN 37180
615/294-5090

PRICE: $49.95; 8087/80287 and non-8087/287 versions, $59.95



CIRCLE 363 ON READER SERVICE CARD

The idea of a memory-resident programmable calculator that can insert results of complex calculations into a report or spreadsheet is attractive. K Software House implements this idea in the KSH-1 Scientific Calculator, a memory-resident program that emulates—

with some extensions—the Hewlett-Packard HP-11C hand-held calculator.

The user presses a hot key to invoke KSH-1, which then accepts input from either the keyboard or an optional mouse (Microsoft or Mouse Systems is supported). After calculations are performed, the results can be transferred to the original application. During testing for this review, this feature worked with Lotus 1-2-3 and Satellite Software International's WordPerfect. It would not work, however, with Microsoft Word. In addition to operating KSH-1 in direct-entry mode, the user can run, store, and retrieve with the utility.

The basic flaw of KSH-1 is its awkward user interface. The design of a hand-held calculator involves compromise. Size and functionality must be weighed continually against each other. In the HP-11C, for example, most keys provide three functions, which conserves space on the calculator's keyboard but necessitates the use of two Shift keys. In choosing to emulate the HP-11C, the authors of KSH-1 are subject to these same design limitations.

The user can accept the limitations of a hand-held calculator as a fair trade-off for the compact physical size. For the PC user, physical size is not a factor—speed and user friendliness are more important considerations. KSH-1 lacks an adequate user interface.

KSH-1 is easily installed. A configuration program is run once to specify if the user desires graphics, if a color monitor is attached to the system, if a mouse will be used for input, and which hot key combination is desired. The program requires 50 to 65KB, depending upon system configuration.

The calculator can be operated with the keyboard alone or with a combination of the keyboard and a mouse. When the user is working only from the keyboard, numeric keypad cursor keys are used to move the cursor among the calculator keys. The Space Bar is used to press each calculator key. Numbers and functions also can be entered directly from the keyboard. A table that lists the key combinations for each of the functions is provided in the README.DOC file on the program diskette. This table must be kept handy because the key combinations are not recognizable. For example, the COSH function is invoked by typing **f j m**.

When the user is working with the keyboard/mouse combination, the mouse can be used to move the cursor; the left mouse button pushes the calculator key, while the right button pushes

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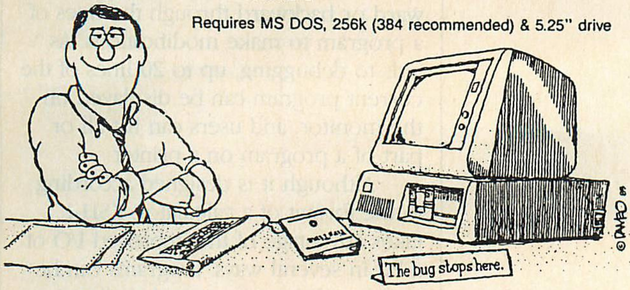

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CIRCLE NO. 158 ON READER SERVICE CARD

the KSH-1 Enter key. The mouse makes KSH-1 easier to use, but the calculator responds slowly to the instructions from the mouse. Another drawback is that the mouse tends to run along rows and columns; sliding it diagonally across the calculator is more difficult.

In addition to the direct-entry mode, KSH-1 provides a mode in which users can enter and edit HP-11C programs. KSH-1 accepts programs of up to 512 steps. Users load programs by pressing the appropriate numeral and function keys. Editing a program is straightforward—users single step forward or backward through the lines of a program to make modifications. As aids to debugging, up to 20 lines of the current program can be displayed on the monitor, and users can list all or part of a program on a printer.

Although it is designed according to the format of a calculator, KSH-1 takes advantage of the improved I/O of a PC in several ways. Programs can be saved to disk and restored. A directory of all files in a subdirectory can be requested from within KSH-1, and the four stack registers can be displayed constantly on the screen.

One nice feature that KSH-1 offers over the HP-11C is the ability to perform hex, octal, and binary arithmetic. A significant drawback, however, is that only unsigned numbers are supported. KSH-1 also supports Boolean and Shift operators. The program carries out calculations to 18 decimal digits of accuracy; 17 digits can be displayed.

KSH-1 operates with memory-resident utilities, but the program interferes with the DOS 3.1 PRINT function. In addition, the mouse does not operate in the keyboard/mouse mode when the calculator is called while the system is running Microsoft Word. While the hot-key combination used to pop up the calculator is chosen by the user, the combination that exits the calculator while passing a result to the foreground process (ALT-I) is not.

KSH-1 Scientific Calculator is available in both non-8087/80287 and 8087/80287 versions. Neither is copy protected. The program is accompanied by a 93-page reference manual that describes the overall calculator structure, discusses the function of each calculator key, and explains how to enter, edit, store, retrieve, print, and run a program. Error messages are described in one appendix, a reference to each calculator key is included in another.

—JEFFERY W. WILSON

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Systems requires: IBM PC,ST,AT or 100% Compatible-256K, MS DOS 2.0 or higher - 80 column screen. Turbo Pascal 3.0-2 DD/DS Disk Drives.

INDEX TO PRODUCTS

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If you're like most system professionals you're up-to-date about the products in the PC marketplace. You're aware of brand and model differences, are informed about connectivity and compatibility problems, and you shop for competitive prices and fast service.

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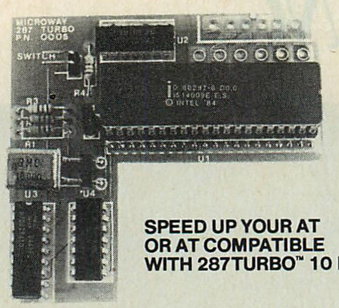

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87BASIC/INLINE™ converts the output of the IBM BASIC Compiler into optimized 8087 inline code which executes up to seven times faster than 87BASIC. Supports separately compiled inline subroutines which are located in their own segments and can contain up to 64 Kbytes of code. This allows programs greater than 128K! Requires the IBM BASIC Compiler Version 1 and a Macro Assembler. Includes 87BASIC ... **$200**

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All MicroWay 8087s include a one year warranty, complete MicroWay Test Program and accurate installation instructions.

8087 5 MHz **$109**
For the IBM PC, XT and compatibles.

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For the IBM PC AT and 286 compatibles.

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For 8 MHz AT compatibles.

80287-8 8 MHz **$295**
For the 8 MHz 80286 accelerator cards.

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287Turbo™ 10 MHz If you own an AT, Deskpro 286 or AT compatible, this is the card you need to get reasonable numeric performance. It plugs into your 80287 socket and includes a specially driven 10 MHz 80287. The card comes in three configurations. The IBM AT version includes a hardware RESET button **$450**

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87/88Turbo™ is a stubby card which includes a clock calendar and a speed controller which changes the speed of your motherboard from 4.77 to 7.4 MHz. Its use requires your PC to have a socketed 8284. Typical speed increase is 1.6 to 2.0. The card overcomes slow hardware by slowing up only when such devices are accessed and running at full speed otherwise **$149**
Optional 8087-2 .... **$149**

286TurboCache™ This new MicroWay accelerator uses 8K of cache memory and 80286/80287 processors to provide an average speed increase of 3:1 for most programs. Call for specifications and benchmarks **$595**

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BRIEF *Is Anything But. A Whopper of an Editor*

With a name that belies its thoroughness, Brief™ has every feature you've ever contemplated for your editor-in-chief. Text, from keyboard or files, is housed in multiple buffers, and scrolled through one or more windows you open, close, resize. A text buffer may be called to different windows to view two areas at once. A change in one changes both. Text blocks may be marked for printing, writing to files, movement to scrap buffers for cut and paste into other buffers, or deletion, with as many "undo" levels as you want.

To find and fix, Brief has text search abilities rivaling "grep", with wildcards for matching, indifference to intervening characters, acceptance of character ranges, even multiple choice of patterns and their replacements.

If you use Lattice, C86™, or Wizard, and have 320k, you can compile your C program without ever leaving Brief. It finds the lines with errors, and marches you through the text for repairs.

Parts of Brief were written with its own Lisp-like macro language which has structure, 32-character variable names, conditional execution, loops, and you can actually read it! Nothing like the hieroglyphs we've seen elsewhere. Bulletin board and public domain disks with macros. Disk of contest-winning macros comes free with your purchase! "Simply the best text editor you can buy", Dvorak *Infoworld*. (Needs 192k.)

Ask for:	List:	PC Brand:
U0590	$195	**$CALL**

MULTI-HALO *Multi-Board Graphics Library*

The premier graphics library that got the ball rolling for PC-based graphics and has grown so omnipotent that it supports over 25 graphics boards — including IBM's EGA and Nr. 9 Revolution's hi-res series — and has a multitude of mouse and printer drivers. All that in each box. Separate C versions for Lattice, M'soft, Aztec, CI86. What does Multi-Halo do? Just about anything. A full "paint" was written using it. Wonderful value for single license. Costly royalties though for redistribution. Specify: S0315 & Language. List: **$250.** We: **$199.**

WINDOWS for C/WINDOWS for DATA *Give Your Program a Clearer Outlook* FREE DEMO!

Windows for C™ is a library of over 65 functions to add the pizazz and practicality of window partitioning to your application. Unlimited windows, each defined in a C structure for easy reference throughout your program, can be made either to pop up or permanently overwrite the screen. Routines will scroll and highlight lists with arrow keys, will read and scroll ASCII files vertically and horizontally in windows, and even write to memory-loaded files off the screen.

Logical treatment of video attributes permits unchanged programs to run on color or monochrome. Colors of windows are set individually.

All functions are in separate modules; only those used are linked. Only buffers holding on-screen or temporarily obscured windows occupy RAM; others released dynamically. TopView™ compatible. Best overall rating and fastest display in Bill Hunt's 7/85 *Tech Journal* review of five windowing products.

Windows for Data comprises all of Windows for C but takes in data through the windows as well. At the high level a single function lets you specify prompt string, field length, data type, screen location, picture, target variable, then sets lesser functions scurrying to get and process a user's input — any of which functions are available directly. There are utilities to get system date and time, mess with strings, create your own field masks.

Field options can require entry, prevent entry, permit insert or overtype, beeping on invalid or overflow keystrokes, and attachment of field-specific help messages and functions you want called to display messages or validate entries. And you decide which keys will clear a field, jump to the next or prior, quit, etc. Options diverse enough that a set of "fields" can be made to behave like a Lotus™ menu.

Many compilers. Free demo.

Specify Compiler:	List:	PC Brand:
T0100 Windows for C	$195	**$169**
T0150 Windows for Data	$295	**$259**

C-WORTHY LIBRARY FREE DEMO! *Fits Out Applications with Shipshape Interface*

Many libraries launch flotillas of functions for small crafting — re-working of strings, positioning the cursor, etc. C-Worthy, by contrast, is a formidable battle wagon for major C engagements.

The C-Worthy Library™ wraps an entire user interface around your application. Its full power can be summoned by only a few high level calls. Sound exaggerated? A single function call can set up a complete text editor in a screen window.

- High level calls pop menus and scrollable choice lists to the screen, restoring the background when dismissed, and branching to the chosen activity in your application. A full function set handles doubly-linked lists defined by C structures.
- Windowing facilities open portholes of up to screen size for viewing virtual screens larger than the physical screen.
- Full context-sensitive help screen management takes over this chore. Keyboard entry routines look for the help key on their own and interrupt with pageable text windows explaining what to do next.
- Full error message interface sends error codes and the functions which return them to C-Worthy which counsels user; you get to remove all that error-checking clutter from your core program.

Your application is nested in these powerful emissaries to the outside world. C-Worthy's imaginative architecture then makes heavy use of C's pointers to functions to find its way into your application to act upon the user's request.

Separate utilities maintain help and error message text and lists in files. This text segregation means applications can readily translate into foreign languages without reprogramming — doubly so because C-Worthy display routines automatically resize for text length.

Where the high level interface does not suit you, the low level routines are available as decomposed functions. All machine dependency such as key mapping is housed in interchangeable overlays loaded alongside the application at run-time; C-Worthy applications can thus run on a mix of PC and MS-DOS machines without recompilation.

C-Worthy hands you a consistent and intuitive interface and a revolutionary design approach. Novell found it "played a key role and accelerated development" in making its NetWare™ utilities easier for users. "You owe it to yourselves to take a look." Binary. Lattice. Others coming. Ingenious demo: call for it.

Ask for:	List:	PC Brand:
T0500	$295	**$269**
T0550 Novell Network	$495	**$449**

C-TREE *B-Tree File Manager, Source Code, No Royalties!*

C-tree™ has been around since 1979. (It became Digital Research's Access Manager™). That means seasoned, sturdy code which hasn't cracked under the weight of prolonged and widespread use. C-tree comes in C source code, revealing all you've ever wanted to know about how b-trees are written. Provided you bind it into your binary application, you can redistribute C-tree without royalties.

C-tree's design splits nodes to allow any number of users to access an index file simultaneously even when updates are in progress. So multi-user configurations and adaptation to networks are possible. You must write record-locking routines, as they are compiler and operating system dependent, but shows how.

Thanks to source code which does not deviate from the K&R standard, C-tree can travel. Tests in many environments prove that C-tree gives your application a ticket to anywhere.

C-tree permits any number of keys for a data file, supports duplicate keys, variable record length files, multiple key indexes in a single file, etc., etc. — it's a comprehensive product with everything you'd expect. Intelligently designed, too. Both high level ISAM routines which minimize coding by handling all details of an activity; as well as decomposed step-by-step functions you can access directly. Either way C-tree maintains optimal index structures which will find the record you seek amongst a million ten-byte keys in no more than five disk seeks.

Ask for:	List:	PC Brand:
F0660	$395	**$329**

dBC *Lattice Library Maintains dBASE Compatible Files With the Power and Speed of C*

dBC™ links C to dBASE. It creates and maintains files and their indexes which exactly replicate dBASE file design. So dBASE can read and update them. And the reverse. dBC can use any files created by dBASE. Now C and dBASE can operate on the same data bases interchangeably.

That opens up the widespread culture of dBASE installations to exploitation by C programmers. You can tap that market, avoid the resident dBASE language, and gain all the advantages of C with this single product.

dBC's functions parallel all dBASE's file handling commands, many decomposed to give closer control. The manual discusses each backed by demo source files on disk.

Use dBC for custom work for clients, or on its own. It's a complete ISAM file manager for C whether or not dBASE will be used in tandem, supports all four memory models, and can have sixteen index and data files open. Big discount to buyers of both dBASE II and III versions. Specify Lattice, Microsoft 3.x, or DeSmet.

Versions:		List:	PC Brand:
L00II	For dBASE II	$250	**$195**
LCCII	With Source	$500	**$390**
L0III	For dBASE III	$250	**$195**
LCIII	With Source	$500	**$390**

CURSES *Unix Style Screen Management*

Curses from Lattice™ manages the screen of the PC like Unix™ curses. Library of 84 functions and macros parallels Unix with matching parameter lists. So your Unix program will feel at home when you move it to the PC, and programs created on the PC will be Unix compatible. Keeps any number of screen images in memory, full or partial size. Supports color, all four memory models. Vast function set to get characters, wrap lines, scroll, blank lines, highlight, etc. Carefully follows Unix curses terminal orientation by re-painting physical screen only on your refresh command.

Ask for: L0850. List: **$125.** Here: **$99.** With Source: L0860, **$250 / $199.**

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TODAY's TOP QUALITY AIDS TO PROGRAMMING PRODUCTIVITY

PRE-C

Thorough "Lint"-like Analysis Now on the PC

Unix users have always had "lint" to thoroughly clean programs before they disappear into a compiler.

Pre-C™ looms larger than "lint". It finds problems your compiler won't. Problems that a debugger will have trouble figuring out. Even problems which will cause trouble with other compilers.

Pre-C finds all the syntactical tripwires that will blow out a compiler and much subtler problems: code which will never be accessed, casts with suspect conversions, variables declared as external but never used, functions never called, machine-dependent expressions which inhibit portability, obsolete usage.

But the big service of "lint" is this: Compilers work with one module at a time. They know nothing of other modules which only meet up at link time. Pre-C looks at *all segments of your program at once* and reports to you any inconsistencies of inter-module references like conflicting data type declarations; parameter lists in calls which disagree with the functions themselves in number or data type.

Pre-C uses the Unix System III compiler standard to guarantee maximum portability anywhere in the C world. Plentiful command line options relax such rigor during early coding when work is incomplete.

Use purchased binary libraries? Profile them for Pre-C and it will thereafter insure that function calls from any C program are letter perfect. A miracle worker in speeding large system development. Needs 128k minimum; 192k recommended.

Ask for:	List:	PC Brand:
P0590	$395	$295

DAN BRICKLIN'S DEMO PROGRAM

Slide Show Your Latest Greatest Idea

INDISPENSABLE!

When the inventor of the electronic spreadsheet called with a new program, we sat straight up in our chair. VisiCalc™ was for businessmen, but Dan's latest is for us programmers.

Ever had trouble putting a program idea into words? Programs are screens! Words don't work. The answer? Show your program as a procession of screens.

Dan's new program makes it easy. It creates slide shows that imitate a program's screens and sequential activity. Create a screen — a snapshot of your planned product as it runs. Anything goes: words, borders, box rules, inverse and underlining of monochrome, foreground and background color on the CGA and EGA. Press a key and make a copy of this "slide", change it a little, by a single character perhaps, to show the next instant of run-time, then copy the slide forward again. Create a whole slide show of your program in action. It will seem like the program itself is running.

Each screen is in 80x25 character mode, not bit-mapped graphics. All 250 characters and attributes are available from scrollable lists which pop to the screen. All commands are layered in Lotus-style pop-up menus, with frequent choices mapped to the function keys as well.

Screen areas can be blocked for cut and paste or filled with color or characters, even made to blink. Slides of oft-appearing segments can be made for overlaying on other slides, and any slide may have several overlays assigned to it. Slides can be shuffled, deleted . . . many quick tools to save time, disk space.

Slides can proceed at time intervals or in response to keystrokes, and depending on a user's response, you can tell the program to branch anywhere in the slide sequence to create innumerable paths through your show.

Don't make your ideas struggle through coding to get to the screen. Dan's Demo is invaluable to prototype the program you are about to write, to position all the labels, choose the color decor, smooth out the keystroke interface *before* it gets etched in code. Or load the "capture" utility above the operating system, snapshot the screens of any running program, and load an instant slide show into Dan's program. Makes tutorials a snap.

Dan's Demo has blossomed throughout Lotus™, we hear. "Lotus [was] my major test site", says Bricklin.

Each purchase entitles you to redistribute fifty copies of the slide projector program along with your show. Plain manual, no binder, to keep the price low because Dan thinks everyone should have one (he's right!). You'll wish he had Demo then and left VisiCalc for now. (Needs 256k).

Ask for:	List:	PC Brand:
N0100	$75	$69

BASTOC

OPTIMIZES!

Translates BASIC Programs Into C

For a trifling price, BASTOC™ will move truckloads of BASIC code over to C. It is a translator which takes in Microsoft Extended or CBASIC and emits pure Kernighan & Ritchie C for the Lattice compiler. It will optionally convert your program into a single monolithic C function or will decompose it into separate functions, one for each GOSUB label.

Version 2.0 adds optimization, with dramatic reductions in execution time. It converts to C integers those numeric variables it finds in BASIC programs which really do not need floating point. It eliminates unreachable code. Where BASIC uses full assignment statements to increment and decrement counter, BASTOC converts to C's compact form, nested in other statements. Strings are dynamically allocated in the target program, ridding your application of BASIC's catatonic halts for garbage collection.

BASTOC will try to create structure of even the most convoluted BASIC code, and writes any indigestible statement into the C output as a comment accompanied by an explanation of the problem. Also, you can optionally tell BASTOC to insert BASIC source lines into the C target as comments, a dandy way to learn the differences between the languages.

Specify:	List:	PC Brand:
S0375 & Which BASIC	$495	$399

BTRIEVE

VERSION 4.0!

Queen-B File Manager Abdicates Royalties

This queen of b-tree file managers was unapproachable to programmers for whom royalties would ruin profit margins.

So it's quite a ukase indeed that one need no longer pay a tithe to incorporate Btrieve™ in applications.

Now there is version 4.0, which hugely speeds DOS interaction, especially for large files with multiple keys. It also adds support for variable length records of virtually any length. Other new features: a read after write option to verify accuracy, useful in gritty environments like manufacturing floors; file password to deny unauthorized access or read only; and data encryption to assure network privacy.

Btrieve's foundation is a balanced-tree indexing scheme, conceded to be the fastest search technique devised (it will find any key in a million-plus item index in four or less accesses). Btrieve takes complete charge of all file creation, indexing, reading, writing, insertion, deletion, space recapture, and forward and backward searching based on full or partial keys. It builds commands right into the language you use in the form of functions you call to tell Btrieve what to do.

Btrieve has mainframe specifications! A single file may have up to 24 indexes. Segments of keys may be indexed. Each index can independently accept or block duplicate keys. Fixed record lengths can be up to 4090 characters; variable length records 64k; indexes 255 characters; files up to 4 billion bytes. It can even extend a file across two drives—even two hard disks!

Interfaces to C, Pascal, BASIC, and COBOL with single purchase; sample programs in all four languages.

The network version works with any network that supports the MS-DOS 3.1 file sharing function.

Code:	Version:	List Price:	PC Brand:
S0650		$245	$199
S0652	Network	$595	$529

PLINK86 & PLUS

Dynamic Cache Overlays Maximize Memory Use

Plink86,™ long the overlord of overlay linkers, now has a Plus version. As a linker Plink can be used with any compiled language which delivers Microsoft/Intel format object files. It yields automatic symbol tables and more memory maps than DOS LINK, but its overlay power has won its reputation as a miracle worker. Plink86 shoe-horns large programs into small memory by binding into your compiled program an overlay manager which knows how to swap modules of large linked programs between disk and shared memory space. Plink86's straightforward overlay description language allows you to describe your overlay hierarchy in a structure permitting up to 4,095 overlays stacked 32 deep.

So if your program needs large chunks of memory, you no longer forego sales to folks who have less. But if you've assumed 128k, and they have 640k, Plink86-Plus™ knows to use extra memory as cache for overlays — at full speed compared to disk swapping. It also can automatically restore a displaced overlay to which a subsequently called overlay must return, and assign library modules to either a program's root segment or overlay areas.

Plink, the programmer's choice even when CP/M™ was the poobah of

Code:	Product:	List Price:	PC Brand:
S0500	Plink86	$395	$289
S0499	Plink86 Plus	$495	$359

GREENLEAF LIBRARIES

FUNCTIONS

New 3.0 has 225 functions in *both C and assembler source* as well as library format. We have versions for Lattice, Microsoft, C86, Mark Wms. New emphasis on tighter functional groupings to minimize excess baggage of functions loaded whether used or not. Manual's 250 pages now help select functions, as do demos and bulletin board. 32 DOS extensions: file and directory manipulation for 2.0 and 1.1. 23 Screen Functions: Select mode, page, monochrome or color, palette; cursor shape, positioning; clearing and scrolling; pixel get and put; read light pen. 60 String Functions: Manipulation of strings, including center and justify; efficient list operations which add, delete, and sort pointers to strings for top speed. 50 Graphic & Printing Functions: Primitives to access all graphics; typeface, formatting, and forms control. Plus keyboard status and function key assignment, time and date algorithms, read registers, memory size, peek and poke.

Ask for:	List:	PC Brand:
S0770	$185	$139

COMMUNICATIONS

Want your application to communicate with other users or remote date bases? Now you can build asynchronous communications right into your C programs! Over 60 functions and demo programs *in both C and assembler source code* set up an interrupt driven scheme with separate transmit and receive ring buffers (characters are simultaneously loaded at one end and transmitted from the other, or vice versa) for an arbitrary number of ports. Interrupt control means you can download a record, then halt the incoming stream to file it, display it, let the user tamper with it, send it back up line. It all happens within the context of *your* program. Goodbye separate communications software.

The Greenleaf Comm Library supports ASCII or binary, any parity, any word length, 8250 UARTs, all four Lattice C memory models, Hayes 300,1200,1200B and other modems.

Its 80-page manual has examples of each function and guides you through asynchronous communications.

Ask for:	List:	PC Brand:
S0750	$185	$139

PANEL

Feature-Laden Screen Design Tool

The newest version of this premier programming tool lets you layer your screen designs with up to ten overlapping images, making it easy to background a screen with pop-up lists, help boxes, and alternate sets of input fields.

Writing your own screenware is a good way to blow completion dates and profits. Panel™ works with you interactively to set up foolproof screen displays and data entry forms rapidly. It tests your form to prove that it (and test data) behave correctly, then converts the finished work into C source code for incorporation into your application. Compile with Lattice or Microsoft.

Wonderfully diverse attributes may be selected for any field — size, data type, color, of course, but also conversion of input to upper case; clearance of existing data when new entry is started; masks for standard formats (eg, dates, phone numbers); a choice of styles for numeric fields; phrases which fill in when their first letter is typed; multiple-choice lists from which to choose a field fill-in by cursoring a highlighted bar. Fields may be multi-lined (eg, name and address as one field) and scrolled if larger than the screen space allotted them.

Panel builds in a user interface for keystroke movement within and between fields, and supplies extensive validation routines for checking user field entries — in source code, so you can tack on your own unique variants. Screen designs may be dynamically loaded from file, or compiled into a program, and version 6 has optimized code to quicken display speed.

The whole package is wrapped in a monitor and keyboard customization package to tailor your application for other equipment. Panel. A superior productivity tool now bigger than ever.

Ask for:	List:	PC Brand:
S0400	$295	$229

PRICED TO SAVE YOU MONEY, SHIPPED FAST ANYWHERE.

NEW LOWER PRICES!

RUN/C PROFESSIONAL VERSION

Interpreter Now Accesses Binary Libraries

RUN/C was an innovator for converting inaccessible compiled C to an interpreted language as easy to grab hold of as BASIC. Great for learning, but a problem remained for pros An interpreter expects nothing but source code, and that put the vast resource of professional binary libraries off limits.

No longer: RUN/C Professional™ has the tools dynamically to load and unload multiple binary function libraries while in its interpreter. Your code can now reach for functions in the commercial C libraries like C-Food Smorgasbord™ - opposite— potentially any library compiled with Lattice's large model. How? The manual shows how to develop the interface to a library, using the Lattice compiler (a must!). How about your own archive of functions? No reason why not.

The RUN/C Interpreter

The interpreting engine lies at the heart of both the improved original RUN/C and the new Professional version. Its creators had the inspiration to make once formidable C behave on screen much like PC BASIC with a full-screen editor like WordStar®. Just create a program and RUN it. If it stumbles, LIST it, EDIT it, add lines, delete lines, RUN it again, fix it again. Use familiar commands like LOAD, MERGE, SAVE, FILES, even TRON and TRACE, and a free profiler.

RUN/C is ideal for rapid program development. Put up code at high speed, tinker and re-arrange, try out things devil-may-care, and let RUN/C find your typos and malaprops.

RUN/C has a treasury of functions built into the interpreter — over 100 paralleling the most used functions found in standard compiler libraries. So when and if the time comes to compile, your source code will find counterparts.

There are lots more features — system interrupts, a shell command to invoke any operating system command without leaving RUN/C, even the ability to load a preferred editor in parallel and switch back and forth.

RUN/C Standard Version

Straight RUN/C has all above but the Loadable Libraries™ docking module. It utilizes source code only, whether created by its own editor, or from any ASCII file, such as programs you've already written, or commercial libraries which supply source code.

It makes a splendid teacher. The manual has not just instructions how to use RUN/C, but its 500-plus pages provide a thorough-going demonstration of the C language itself. Every feature, of C or RUN/C, is accorded its own micro-chapter. Over 100 of these chapters are devoted to RUN/C's built-in functions, and every one lists a sample program showing how it is used. The programs are also on the disks. So as you read them in the manual, you can run them on the screen. (Needs 180k-256k recommended.)

RUN/C Professional

RUN/C Pro has every feature of RUN/C regular plus the binary library link-up and an extra level of debugging aids. They are ingeniously installed behind a built-in function, so you can call for debugging conditionally. The called function paints a menu of debugging tools to choose from, including immediate mode to display variables, single-step tracing, and changing of variables.

RUN/C Professional can tackle projects of any size. Use it as a creative front end to feed a continuous stream of source code into compiled modules. Only the source work in progress is still interpreted; the finished modules will whiz by at object speeds. It will change how you work. (320k minimum and 512k recommended to fit libraries.)

RUN/C: quite a run for your money.

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LATTICE C VERSION 3.0

Major Upgrades to the Best Selling C Compiler

Lattice has labored and come forth with the long-awaited Version 3.0 of its top-rated compiler. A long list of enhancements, adoption of the ANSI draft standard, documentation rivaled by few, and add-on libraries matched by none in sheer quantity restore Lattice C™ to its leadership role as the C compiler to beat.

Lattice now embraces key UNIX™ enhancements which have entered the language since Kernighan & Ritchie: void functions returning no value, enumerated data types to assign stepped values to variables, the ability to pass data between structures by assignment statements. And 3.0 adopts checking of external function arguments by data type as proposed by ANSI to kill bug swarms when modules join up at link time.

The greatly expanded libraries, now comprising 325 functions(!), enable the file sharing and record locking provisions of DOS 3.1, provide a full complement of transcendentals, and a host of utilities to mimic the UNIX and XENIX™ environments.

Lattice now delivers smaller .EXE files, curing one past complaint, boasts very fast link times and a more efficient aliasing algorithm.

The compiler now defaults to the ANSI proposed standard when you need a strict mistress, but command line options tolerate straying. New options generate code to use 80186 and 80286 features, and the 8087 is of course sensed and utilized if aboard.

Lattice has enjoyed pre-eminence so long that developers have created far more tools to marry into Lattice C than any other compiler. Programmers now have an enormous resource of libraries and utilities to use with Lattice to speed their work. William Hunt, in his exhaustive analysis of 12 compilers in the 1/86 issue of the *PC Tech Journal* awards Lattice the only "very good" rating for add-on library availability. He sums up with this all-around accolade: "a fine product to consider for the production of important applications."

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New Version Compatible with Microsoft BASICs

This hearty implementation provides a real alternative to technical languages like C. It melds the most useful features of C, Pascal, and Modula 2 into BASIC, while retaining the familiarity of a language already known to millions. And now Version 2.0 is 100% compatible with Microsoft's GW™ BASIC and IBM BASICA including graphics, sound, and assembly language calls. Just load old programs and run. Save and they are converted to BetterBASIC.

It's big: BetterBASIC's hugely expanded features require 192k; your programs can go all the way to the PC's full 640k. It's comfy: Behaves like Microsoft BASIC at the interactive level, with a full-screen editor, direct statement execution, and always poised to RUN. It's fast: BB is an incremental compiler—unlike with interpreters each statement is checked and compiled just once. The Sieve benchmark runs *six times faster* than with Microsoft.

BetterBASIC® has C-like structures for reference to entire records so say goodbye to FIELD, MKI$, CVD, LSET, etc. It has "procedures" summoned by name unlike GOSUBs. Lots more features: built-in linker for compiled modules; trace; debugging breakpoints; cross-reference command; 32k strings; DOS and BIOS calls and interrupts; recursion.

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GSS Kernel™ conforms to level 2b of ANSI's Graphical Kernel System (GKS) and contains all its needed drivers and language bindings. Kernel has macro level tools to draw and color an object, store the sequential instructions, and recreate the object on its own, as well as segment it, transform it, etc., all the while returning data on attribute settings, system and device status. So powerful, a single command may represent several score lower level statements.

Plotting has the equivalent GKS tools for graph and chart generation and their captioning: hand it apples and oranges, say "pie", and it bakes the numbers into a digestible display for screen or plotters.

Kernel and Plotting have tools to convert images they create to ANSI Computer Graphics Metafiles (CGMs), a tokenized standard for storing every form of graphic image as data. The Metafile Interpreter reads the contents of a CGM and interprets it with full CGI capability for re-creation on various devices, and you can cut and paste before display.

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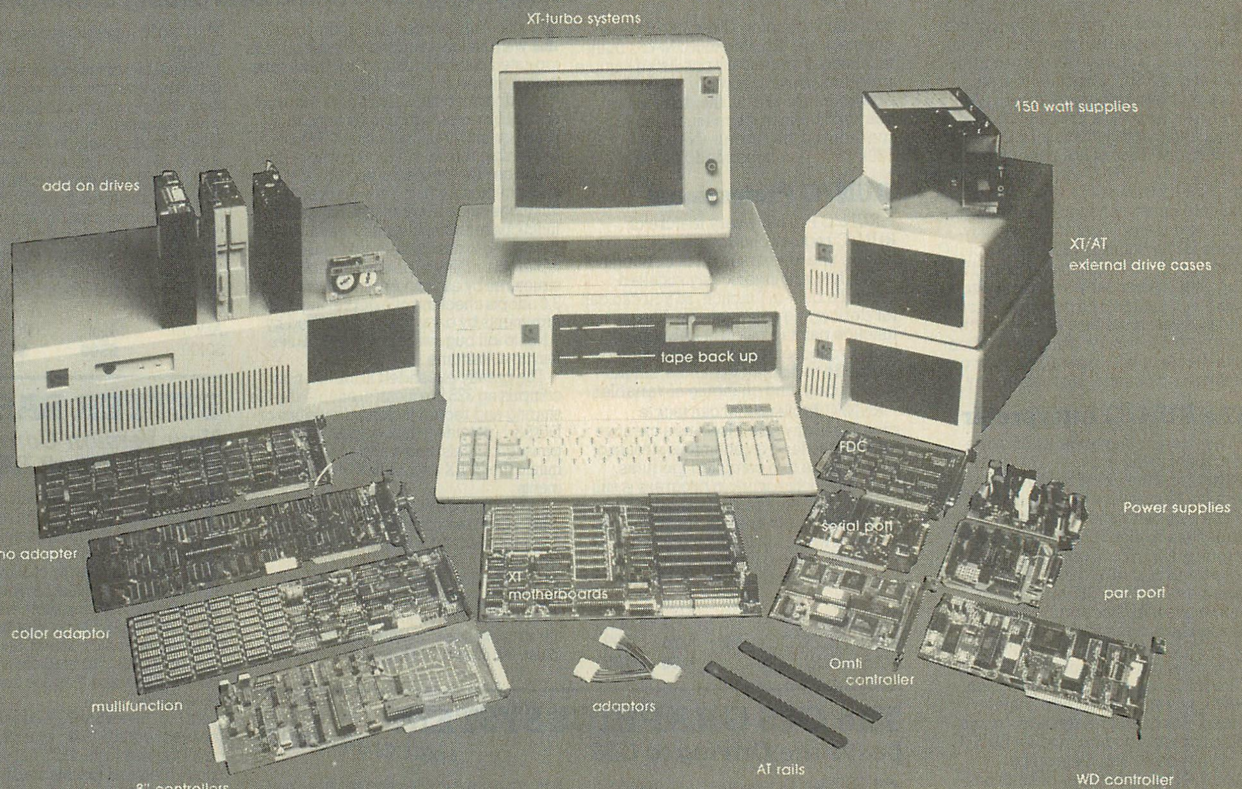

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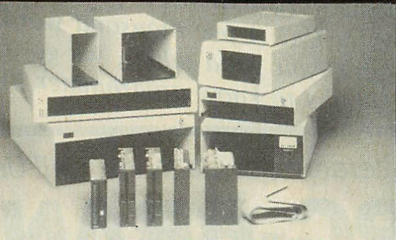

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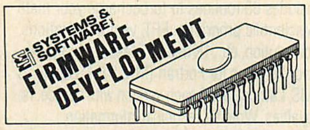

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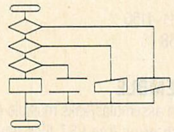

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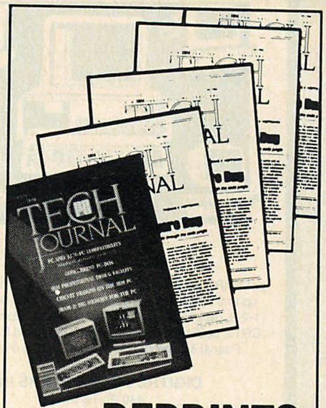

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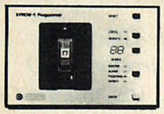

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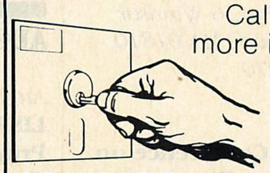

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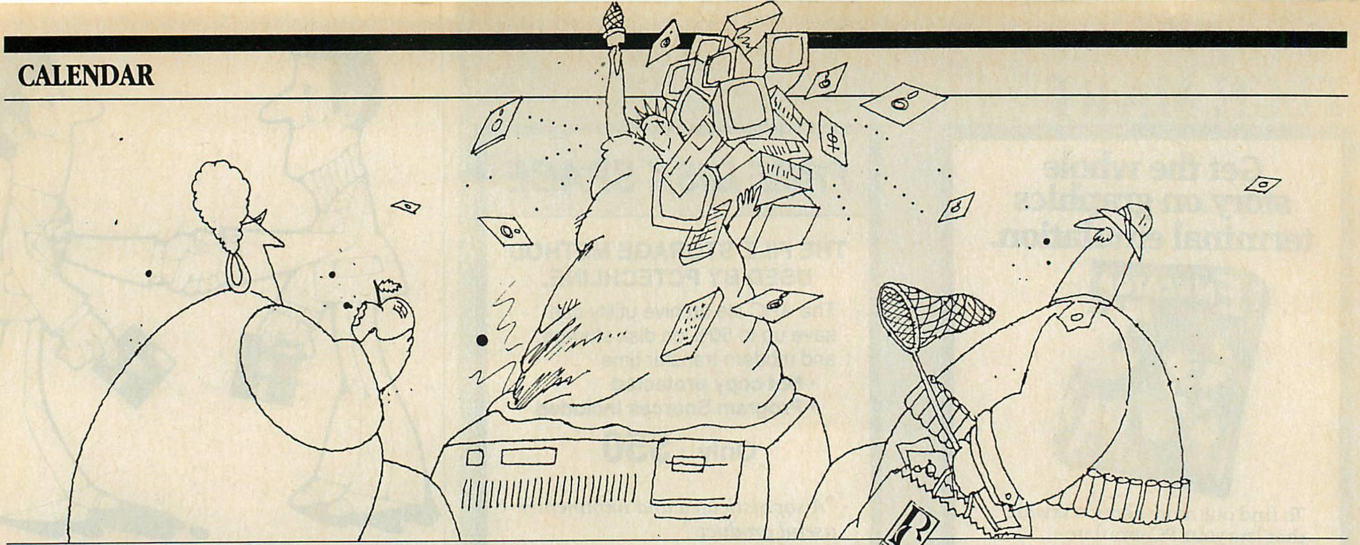

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JULY

July 7-11
APL '86
Manchester, England
Sponsor: British Computer Society and ACM SIGAPL
Contact: BISL Conference Department, The British Computer Society, 13 Mansfield Street, London W1M 0BP, England

July 8-11
UNIX: A Comprehensive Workshop
Washington, DC
Contact: Yolande Amundson, Integrated Computer Systems, 6305 Arizona Place, P.O. Box 45405, Los Angeles, CA 90045; 800/421-8166

July 9-11
PC EXPO
New York, NY
Contact: 333 Sylvan Avenue, Englewood Cliffs, NJ 07632; 201/569-8542

July 14-17
Software Trends for Executive Planning and Strategy
Boston, MA
Sponsor: Digital Consulting Associates, Inc.
Contact: Digital Consulting Associates, Inc., 6 Windsor Street, Andover, MA 01810; 617/470-3870

July 21-25
European Conference on Artificial Intelligence
Brighton, U.K.
Sponsor: European Coordinating Committee on Artificial Intelligence and the Society for the Study of Artificial Intelligence and Simulation Behavior
Contact: Benedict du Boulay, ECAI, The University of Sussex, Cognitive Studies Programme, Brighton BN1 9QN, U.K.

July 21-26
Third International Conference on Logic Programming
London, England
Contact: Doug DeGroot, IBM Research, P.O. Box 218, Yorktown Heights, NY 10598

July 22-25
Ada Programming Workshop
Washington, DC
Sponsor: Integrated Computer Systems
Contact: Yolande Amundson, Integrated Computer Systems, 6305 Arizona Place, P.O. Box 45405, Los Angeles, CA 90045; 800/421-8166

July 27-31
Information Center Conference and Exposition
Anaheim, CA
Contact: Julia Stasio, Weingarten Publications, Inc., 38 Chauncy Street, Boston, MA 02111; 617/542-0146

AUGUST

August 4-6
LISP and Functional Programming
Cambridge, MA
Sponsor: ACM
Contact: Richard P. Gabriel, Lucid, Inc., 707 Laurel Street, menlo Park, CA 94025

August 5-7
ACM SIGCOMM Futures in Communications Conference
Stowe, VT
Contact: Walter Kosinsky, Norwich University, Northfield, VT 05663; 802/485-5011, ext. 237

August 11-13
Symposium on Principles of Distributed Computing
Calgary, Alberta, Canada
Sponsor: ACM SIGACT-SIGOPS
Contact: ACM, 11 West 42nd Street, New York, NY 10036

August 18-22
13th Annual Conference on Computer Graphics and Interactive Techniques
Dallas, TX
Contact: SIGGRAPH '86 Conference Management, 111 E. Wacker Drive, #600, Chicago, IL 60601; 312/644-6610

SEPTEMBER

September 1-5
World Computer Conference
Dublin, Ireland
Sponsor: International Federation for Information Processing
Contact: IFIP Congress '86, 1899 Preston White Drive, Reston, VA 22091; 703/620-8900

September 8-10
NCC-Telecommunications Conference
Philadelphia, PA
Sponsor: AFIPS, ACM, DPMA, IEEE, SCS
Contact: Mike Sherman, AFIPS, 1899 Preston White Drive, Reston, VA 22091; 703/620-8935

September 30-October 2
Northcon '86
Seattle, WA
Contact: Dale Litherland, Education Director, 8110 Airport Blvd., Los Angeles, CA 90045; 800/421-6816, in California, 800/262-4208

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Expert Systems in Government Conference
McLean, VA
(October 20-24)
Sponsor: IEEE-CS
Contact: Dr. Kamal N. Karna, Communications and Computer Graphics, 823 Flagler Drive, Gaithersburg, MD 20708; 301/921-0392

August 31, 1986
Computers and Applications
Peking, China
(June 24-26)
Sponsor: IEEE-CS and Chinese Computer Federation
Submit papers to: Oscar N. Garcia, Department of EE and CS, Room T-637, The George Washington University, 801 22nd Street N.W., Washington, DC 20052; 202/676-7175

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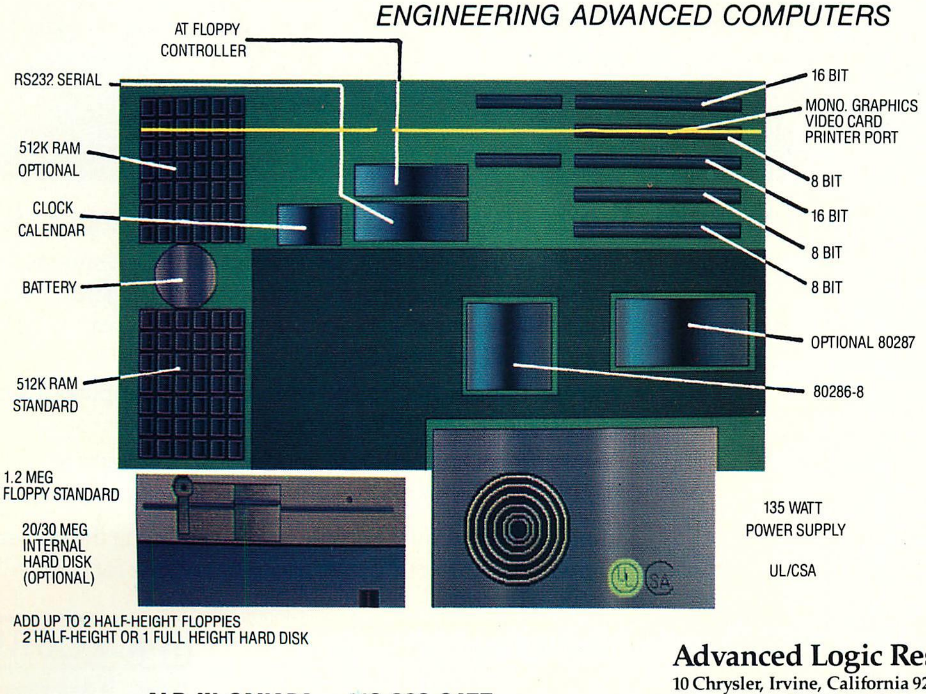

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